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(21) International Application Number: PCT/US93/03650 (22) International Filing Date: 16 April 1993 (16.04.93) (30) Priority data: 869,697 16 April 1992 (16.04.92) US (71) Applicant: RESEARCH CORPORATION TECHNOLOGIES, INC. [US/US]; 101 N. Wilmot Road, Suite 600, Tucson, AZ 85711-3335 (US). (72) Inventors: PIDGEON, Charles ; 515 Evergreen Lane, West LaFayette, IN 47906 (US). MARKOVICH, Robert, J. ; 27 Rachel Court, Franklin Park, NJ 08823 (US).		(74) Agent: SCOTT, Anthony, C.; Scully, Scott, Murphy & Presser, 400 Garden City Plaza, Garden City, NY 11530 (US). (81) Designated States: CA, JP, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE). Published <i>With international search report.</i>
(54) Title: NOVEL ACYLATED PHOSPHOLIPID DRUGS <div style="text-align: center;">$\begin{array}{c} \text{O} \\ \parallel \\ \text{O}-\text{P}-\text{OR} \\ \\ \text{OH} \\ \text{CH}_2-\text{CH}-\text{CH}_2 \\ \quad \\ \text{OR}_1 \quad \text{OR}_2 \end{array}$</div> (57) Abstract <p>The invention relates to a compound having formula (A) or pharmaceutically acceptable salts thereof, wherein one of R₁ and R₂ is a heteroatom fatty acid acyl group having 13-14 carbon atoms in the principal chain and up to a total of 18 carbon atoms, while the other is hydrogen, a heteroatom of fatty acid acyl group containing 13-14 carbon atoms in the principal chain and up to a total of 18 carbon atoms or an acyl group of a fatty acid containing 4-26 carbon atoms in the principal chain and up to a total of 30 carbon atoms and R is a naturally occurring polar group characteristic of a glycerolphospholipid isolated from endogenous sources. This invention also relates to the use of the compounds of the present invention for inhibiting retrovirus infections and for the treatment of AIDS or AIDS related diseases.</p>		

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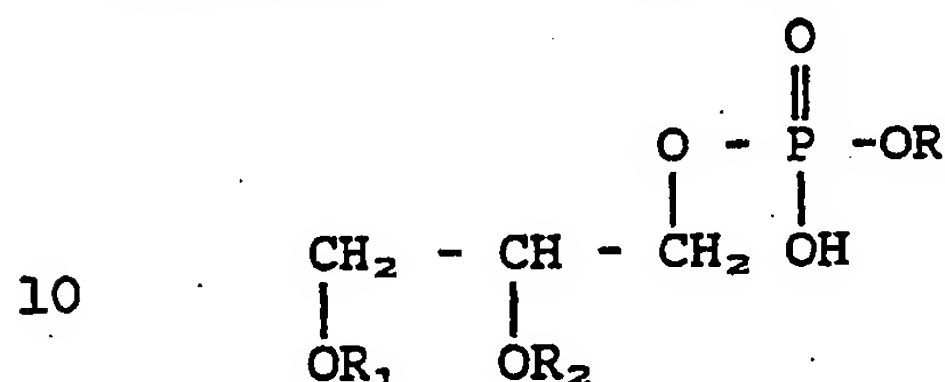
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NOVEL ACYLATED PHOSPHOLIPID DRUGS

The present invention relates to novel glycerol phospholipids useful as a drug for the treatment of AIDS and AIDS related complex. More specifically, the present invention is directed to a compound of the formula:



or pharmaceutically acceptable salts wherein

one of R_1 and R_2 is a heteroatom fatty acid acyl group containing 13-14 carbon atoms in the principal chain and up to a total of 18 carbon atoms, while the other is hydrogen, a heteroatom fatty acid acyl group containing 13-14 carbon atoms in the principal chain and up to a total of 18 carbon atoms or an acyl group of a fatty acid containing 4-26 carbon atoms in the principal chain and up to a total of 30 carbon atoms and

R is a naturally occurring polar group characteristic of a glycerophospholipid isolated from endogenous sources.

The present compounds are useful in the treatment of AIDS. More specifically, the compounds of the present invention possess anti-viral activity especially anti-retroviral activity. Thus, these compounds of the present invention are useful in combatting and/or retarding the growth of retroviruses, such as the human immunodeficiency virus (HIV). As such, the compounds of the present invention are useful

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1 in treatment of acquired immune deficiency syndrome (AIDS) and AIDS-related complex (ARC).

The effectiveness of the compounds of the present invention are illustrated in the following 5 figures, which are discussed in more detail hereinbelow.

Figure 1 depicts the anti-HIV activity in T-cells of AC1, AC2, 1-(12-methoxydodecanoyl)-sn-3-glycerophosphatidylcholine and 12-methoxydodecanoic acid. Results are plotted on mm scale for direct 10 comparison. Toxicity of the compounds in the CEM cells is labelled above each bar as toxic or non-toxic. The % reduction in the direct cytopathic effect of the virus (CPE) is represented on the Y-axis.

Figure 2 shows the anti-HIV activity in 15 macrophages of L-AC1, L-AC2 and 12MO measured with an HIV p24 antigen assay.

Figure 3 depicts the anti-HIV activity of L-AC2 and 12MO in MT-4 cells using syncytial cell assays.

Figure 4 depicts the antiviral activity of L-20 AC2 and 12MO in peripheral blood monocytes (PBMC's) measured by reverse transcriptase assay. The results are depicted as the % of control.

Figure 5 demonstrates the toxicity activity of L-AC2 and 12MO used to evaluate the concentration of 25 drug that kills 50% of MT-4 cells in the absence of virus. Dose response curves were used to evaluate the concentration of drug that kills 50% of MT4 cells. This 50% effective toxicity to cells is denoted as TC50 in each graph.

30 Figure 6 depicts the potent anti-HIV synergism when L-AC2 and AZT are concurrently administered.

1 Figure 7 depicts the anti-HIV activity of D-AC2 (unnatural glycerophosphatidyl choline configuration) and phosphatidylcholine (PE) analogs, L-PE-1 and L-PE-2 compared with 12MO.

5 Figure 8 depicts the stability of various anti-HIV phospholipids, L-PE1, L-AC2, D-AC2 and L-PE2 in fresh blood at 38°C.

 As used herein, the pharmaceutically acceptable salts include the acid and basic salts.
10 Basic salts for pharmaceutical use are potassium, sodium, calcium, magnesium, zinc and the like. Suitable acids include for example, hydrochloric, sulfuric, nitric, benzenesulfonic, toluenesulfonic, acetic, maleic, tartaric and the like which are pharmaceutically
15 acceptable.

 The term "lower alkyl" refers to an alkyl group containing from 1 to 6 carbon atoms and may be straight chain or branched. It includes such groups as methyl, ethyl, propyl, isopropyl, butyl, sec-butyl,
20 isobutyl, t-butyl, pentyl, amyl, hexyl and the like. The preferred lower alkyl group is methyl.

 The term "fatty acid" shall mean a carboxylic acid derived from or contained in animal or vegetable fat or oil. Said fatty acids may be saturated or
25 unsaturated and are composed of a chain of alkyl groups containing from 4 to 26 carbon atoms, usually even numbered. The fatty acids are characterized by a terminal carboxy group. They also may contain a hydroxy group or a second carboxy group. It is preferred that
30 the second carboxy group, when present, is located at the omega (last) carbon position of the principal chain.

1 Examples of fatty acids are described in
SCIENTIFIC TABLES, 7th Edition, published by CIBA-Geigy
Limited, Basle Switzerland, p. 365-372 (1970), and the
contents are incorporated by reference as if fully set
5 forth herein. These examples include the natural
product fatty acids, such as propionic acid, n-butyric
acid, valeric acid, caproic acid, enanthic acid,
caprylic acid, pelargonic acid, capric acid, undecylic
acid, lauric acid, margaric acid, stearic acid,
10 nondecylic acid, arachidic acid, heneicosanoic acid,
behenic acid, tricosanoic acid, lignoceric acid,
pentacosanoic acid, cerotic acid, acrylic acid, trans-
(α)-crotonic acid, iso(β)-crotonic acid, Δ^2 hexenoic
acid, Δ^4 -decenoic acid, Δ^9 -dodecanoic acid, Δ^4
15 dodecanoic acid, Δ^6 -dodecanoic acid, tsuzuic acid,
physteric acid, myristoleic acid, palmitoleic acid,
petroselinic acid, oleic acid, eladic acid, trans- and
cis-vaccenic acid, Δ^{12} -octadecenoic acid, gadoleic
acid, Δ^{11} -eicosenoic acid, cetoleic acid, erucic acid,
20 brassidic acid, selacholeic acid, ximenic acid, sorbic
acid, linoleic acid, hiragonic acid, α -eleosteric acid,
 β -eleostearic acid, linolenic acid, stearidonic acid,
arachidonic acid, behenolic acid, isobutyric acid,
isovaleric acid, tiglic acid, isomyristic acid,
25 anteiomargic acid, tuberculostearic acid, phytanic acid,
myocolipenic acid, myococeranic acid, and the like.
Preferably, the term fatty acid as used herein shall
contain 10 to 22 carbon atoms, and more preferably shall
contain 13 to 18 carbon atoms. Most preferably, the
30 fatty acid shall contain 4-8 carbon atoms or 13-15
carbon atoms.

1 As used herein, the term "fatty acyl of a fatty acid" is defined as a fatty acid in which the carboxy terminus is replaced by an acyl group ($-\overset{\overset{\text{O}}{\parallel}}{\text{C}}-$).

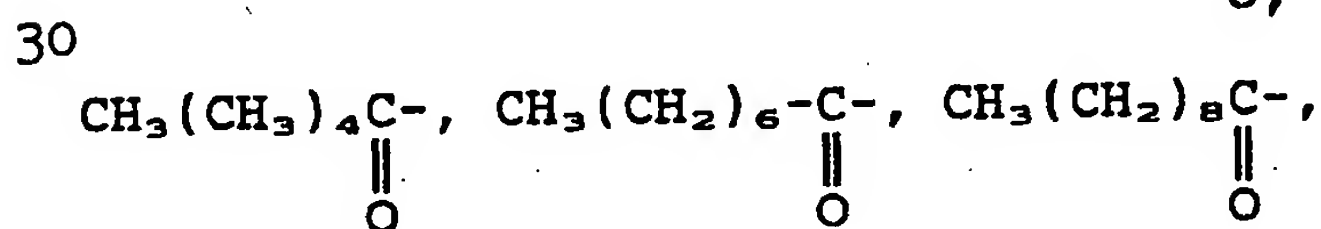
5 In other words, said term has the formula $\overset{\overset{\text{O}}{\parallel}}{\text{C}} - \text{R}_7$,

wherein R_7 is a hydrocarbyl group as defined herein. For example, the fatty acyl of myristic acid is

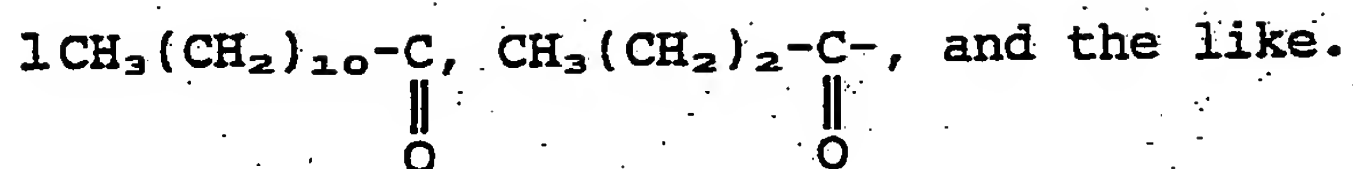


It is preferred that the fatty acids acyl group contains 4-26 carbon atoms. Besides the acyl group, (C), the fatty acid acyl group may contain
 15 $\overset{\overset{\text{O}}{\parallel}}{\text{O}}$
 unsaturation, e.g., double or triple bonds between the carbon atoms, but it is preferred that the fatty acid acyl group contains single bonds between the carbon atoms. In fact, except for the acyl, it is preferred
 20 that this group is a hydrocarbyl group, as defined herein. It is especially preferred that the hydrocarbyl group be saturated and contain 4-16 carbon atoms, and most preferably 4-14 carbon atoms. Finally, it is preferred that the group contains an even number of
 25 carbon atoms.

The fatty acyl group may be straight chained or branched, but it is preferred that it is straight chained. Examples include $\text{CH}_3(\text{CH}_2)_2\overset{\overset{\text{O}}{\parallel}}{\text{C}}-$,



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The term "heteroatom fatty acid" is a biologically active fatty acid analog of myristic acid chosen from a saturated or partially unsaturated fatty acid containing 13-14 carbon atoms, wherein at least one methylene group normally present at position 4 to 13 is replaced by at least one oxygen or sulfur atom. It is preferred that the heteroatom fatty acid contain 1-3 oxygen or sulfur atoms or a combination thereof. It is especially preferred that only one methylene group is replaced by oxygen or sulfur and it is most preferred that said methylene group is replaced by oxygen.

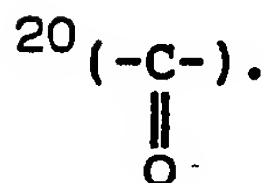
Preferred heteroatom fatty acids employable in the present invention include but are not limited to: 11-(ethylthio)undecanoic acid [$\text{CH}_3\text{CH}_2\text{S}(\text{CH}_2)_{10}\text{COOH}$]; 5-(octylthio)pentanoic acid [$\text{CH}_3(\text{CH}_2)_7\text{S}(\text{CH}_2)_4\text{COOH}$]; 11-(methoxy)undecanoic acid [$\text{CH}_3\text{O}(\text{CH}_2)_{10}\text{COOH}$]; 11-(ethoxy)undecanoic acid [$\text{CH}_3\text{CH}_2\text{O}(\text{CH}_2)_{10}\text{COOH}$]; 12-(methoxy)dodecanoic acid [$\text{CH}_3\text{O}(\text{CH}_2)_{11}\text{COOH}$]; 10-(propylthio)decanoic acid [$\text{CH}_3(\text{CH}_2)_2\text{S}(\text{CH}_2)_9\text{COOH}$]; 10-(propoxy)decanoic acid [$\text{CH}_3(\text{CH}_2)_2\text{O}(\text{CH}_2)_9\text{COOH}$]; 11-(1-butoxy)undecanoic acid [$\text{CH}_3(\text{CH}_2)_3\text{O}(\text{CH}_2)_{10}\text{COOH}$]; [10-(2-propynyloxy) decanoic acid [$\text{HC}\equiv\text{CCH}_2\text{O}(\text{CH}_2)_9\text{COOH}$]; and the like.

Additionally, the term heteroatom fatty acid is a saturated or unsaturated C_{13} to C_{14} fatty acid which is substituted by halo, hydroxy, alkoxy, mercapto or alkylthio. More preferably, the heteroatom fatty acid is a saturated or unsaturated fatty acid containing 13 to 14 carbon atoms which is substituted with halo or

1hydroxy. More preferred heteroatom fatty acids are saturated or unsaturated fatty acids which contain 13 to 14 carbon atoms and are substituted by chloro, bromo or hydroxy. Still more preferred are saturated or unsaturated fatty acids which contain 13 to 14 carbon atoms which are substituted by chloro, bromo or hydroxy at the 2-position.

Additionally, it is to be understood, within the spirit and scope of the present invention, that the term heteroatom fatty acid may also be a C₁₃ to C₁₄ saturated or unsaturated fatty acid wherein a methylene group normally at carbon position 5 to 12 is replaced by oxygen or sulfur, and further, said fatty acid may be substituted, preferably at the 2-position, by halo, hydroxy, alkoxy, mercapto or alkylthio.

The term "alkyl heteroatom fatty acid acyl group" as defined herein is defined as a heteroatom fatty acid containing no multiple carbon-carbon bonds in which the carboxy terminus is replaced by an acyl group



As used herein, the term halo shall mean one or more members of Group VII A of the periodic table, including fluorine, chlorine, bromine, and iodine; most preferably, fluoro or chloro and especially bromo.

The term alkoxy denotes an o-alkyl group, wherein alkyl is defined hereinabove. Examples of alkoxy are methoxy, ethoxy, propoxy, butoxy, pentoxy, hexoxy, and the like.

The term alkylthio is defined as an alkyl, as hereinbefore defined, containing a thio group.

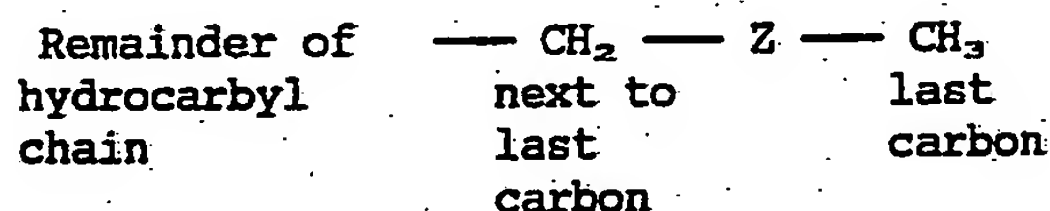
1 The term mercapto shall mean HS.

The term "omega (w) carbon" refers to the last carbon in the principal chain.

The term penultimate carbon refers to the next 5 to last carbon on the principal chain. For example, in the decyl substituent, C₁₀ is the omega carbon while C₉ is the penultimate carbon.

The term "heteroatom is bonded to the penultimate carbon" or any equivalence thereof, means 10 that the heteroatom is bonded between the omega and penultimate carbon. For example, if Z is a heteroatom, and if it is stated that Z is bonded to the penultimate carbon, this means that in the principal chain, Z is located between the last and the next to last carbon:

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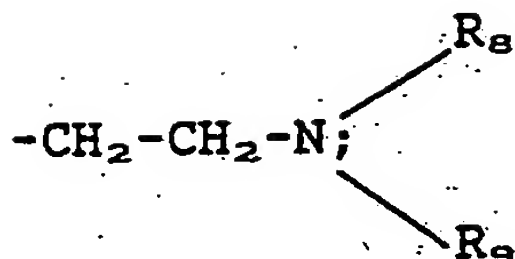


As defined herein, R is part of the polar head 20 group and is a distinguishing portion of a glycerophospholipid. The polar group may be naturally occurring or analogs thereof. There are many types of polar groups on glycerol phospholipids found in nature. The more common R groups thereon are inositol, 25 ethanolamine, choline and serine. But recently other head groups have been found, e.g., N-methyl ethanolamine, N,N-dimethyl ethanolamine, (See Casal et al., Biochemica et Biophysica Acta, 1983, 735, 387-396), and sulfocholine, (See Mantsch et al. Biochemical et 30 Biophysica Acta, 1982, 689, (63-72) and the like. The present invention contemplates these groups found in

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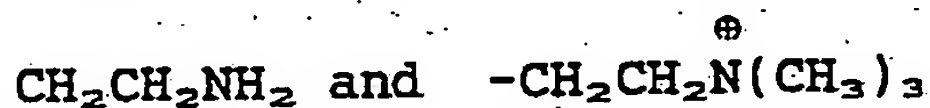
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wherein R_8 and R_9 are independently hydrogen or lower alkyl, and preferably hydrogen. The most preferred are



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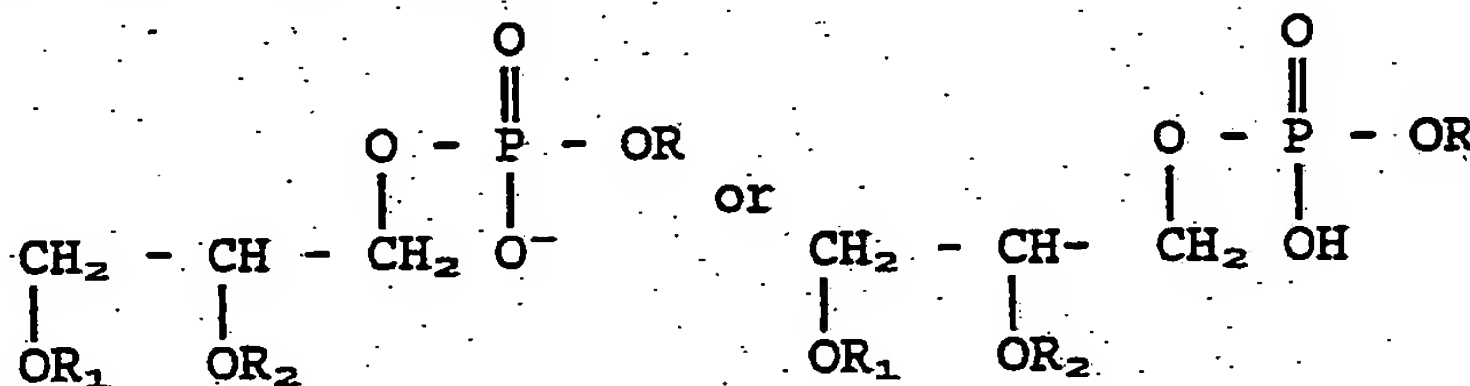
The prefix "sn-" as employed herein is used to denote the carbons of the glycerol backbone of the fatty acid according to the stereospecific numbering system established for lipid nomenclature. In other words, sn-1 denotes the carbon at the first position, sn-2 denotes

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the carbon at the second position, etc.

The phospholipid ester depicted hereinabove can exist in two forms,

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The term "basic salts" contemplates the former form, wherein basic salts are as defined herein. Unless specified to the contrary, the drawing of one form also contemplates to the other form.

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The carbon atom at the sn-2 position of the phospholipid ester depicted hereinabove contains an asymmetric center. Thus, the phospholipid ester as well as carbon atoms may exist in two stereochemical configurations, the L-stereoisomeric form (the natural

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lconfiguration) or the D- form. Both stereoisomeric forms are contemplated by the present invention.

It is to be noted that when R_2 or R_1 is hydrogen, these compounds represent the glyosphospholipids of the present invention.

Of course, there may be additional chiral centers present on the R , R_1 and R_2 groups, which also gives rise to various stereoisomeric forms. These various stereoisomeric forms are also contemplated to be within the scope of the invention. Therefore, all of the various configurations around each chiral center present in the phospholipid compounds of the present invention, including the various enantiomers and diastereomers as well as racemic mixtures and mixtures of enantiomers and/or diastereomers of the compounds of the present invention, either singly or in combination, are contemplated by the present invention.

It is preferred that when R_2 or R_1 is other than hydrogen, R_2 and R_3 are not branched, but are straight chained.

It is preferred that the hydrocarbyl group of the heteroatom fatty acid, i.e., the aliphatic portion of the heteroatom fatty acid, is saturated. When R_2 or R_1 is other than hydrogen, they may be heteroatom fatty acid acyl group or an acyl group of a fatty acid, as defined herein.

When R_1 and R_2 are a fatty acid acyl group, the fatty acid acyl group may have, in one embodiment, 4-8 carbon atoms, or in another embodiment 13-14 carbon atoms. It is also preferred that the alkyl fatty acid acyl group be a hydrocarbyl fatty acid acyl group. Additionally, in an embodiment of the present invention,

1 the fatty acid acyl group has a carboxy substituent at
the omega carbon. It is preferred also that R_1 and R_2
be straight chained.

5 When R_2 or R_1 is a heteroatom fatty acid acyl
group, then this group has the characteristics as
defined herein. It is preferred that the heteroatom
fatty acid acyl group contain no carbon-carbon multiple
bonds. In one embodiment, it is preferred that R_2 and
10 R_1 consist of a hydrocarbyl moiety attached to the acyl.
It is preferred that the hydrocarbyl group is saturated.
It is further preferred that the hydrocarbyl group be a
straight chain. The heteroatom hydrocarbyl group may
contain more than one oxygen atom, sulfur atom or
15 combination thereof in the principal chain, although
oxygen is the preferred heteroatom. It is more
preferred, however, that the principal chain contain
only one oxygen or sulfur. Furthermore, it is preferred
that the heteroatom not be α to the acyl group or be on
the omega position of the chain. It is most preferred
20 that there may be only one heteroatom in the principal
chain and that the heteroatom is oxygen.

Another preferred value of R_1 and R_2 , when
defined as a heteroatom fatty acid acyl group, is the 1-
substituted alkyl fatty acid acyl groups containing 3-
25 25, carbon atoms and the substituents are hydroxy, halo,
lower alkoxy, mercapto or alkylthio. In a more
preferred embodiment, the substituent is hydroxy or
halo, preferably bromo or chloro. In the most preferred
embodiment, the hydrocarbyl chain contains 13-15 carbon
30 atoms and most preferably 13-14 carbon atoms and is 1-
substituted hydroxy or halo.

1 Of course, various combinations and
permutations are possible, as described below, in which
R₁ and R₂ are independently heteroatom alkyl group, 1-
substituted alkyl group or heteroatom 1-substituted
5 alkyl group. These various combinations and
permutations are contemplated to be within the scope of
the present invention.

Preferred embodiments of the present invention
are directed to compounds wherein R is as defined
10 hereinabove, one of R₁ and R₂ is hydrogen, alkyl fatty
acid acyl group having 4-26 carbon atoms, or alkyl
heteroatom fatty acid acyl group having 13-14 carbon
atoms, and the other is independently a heteroatom
hydrocarbyl fatty acid group containing 13-14 carbon
15 atoms containing at least one oxygen or sulfur.

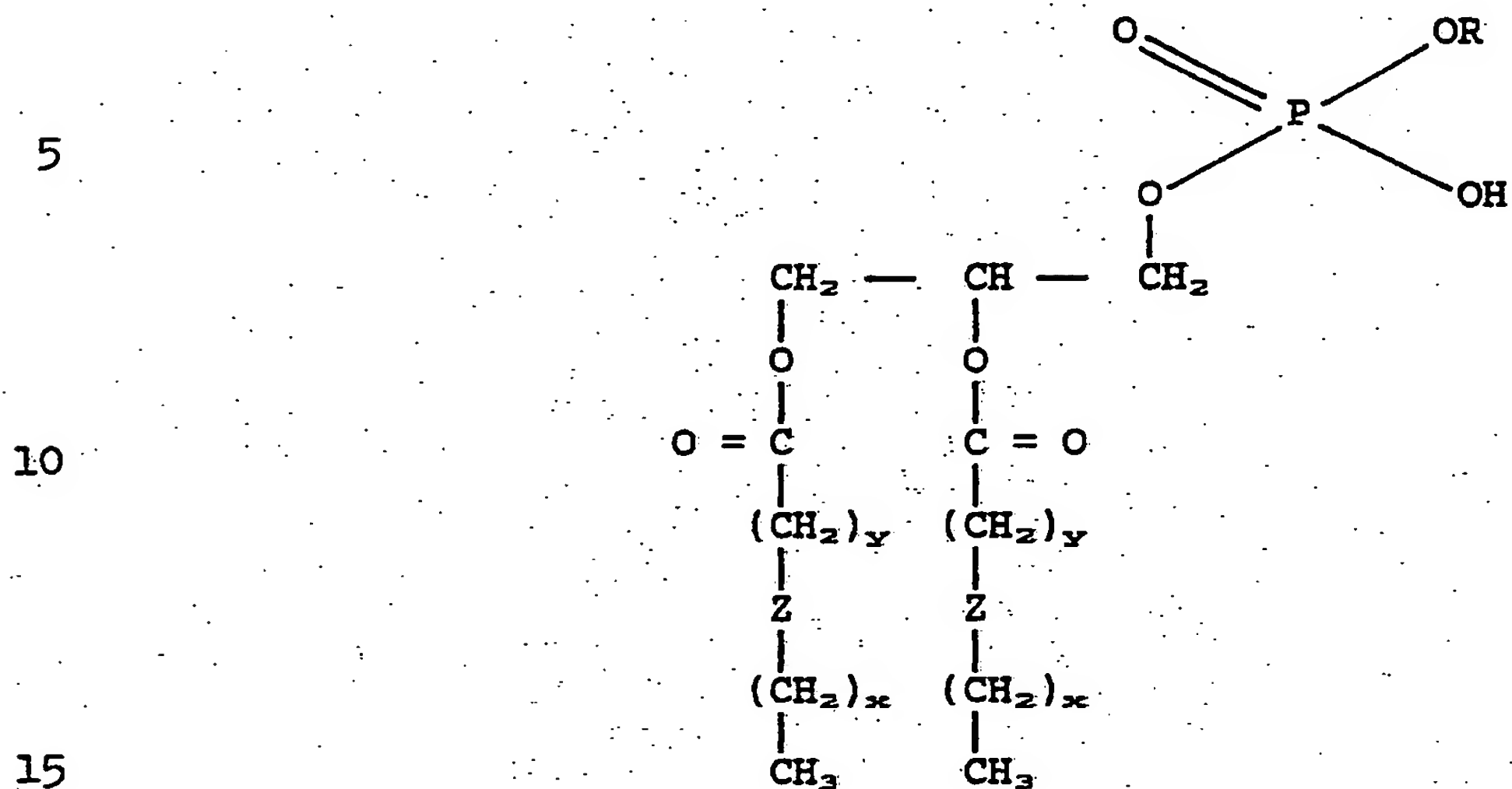
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1 In a further embodiment, the present invention
contemplates a phospholipid drug of the formula:



VIII

wherein R is as defined hereinabove;

Z is oxygen or sulfur;

each x is independently 0 to 13;

20 each y is independently 1 to 13; and

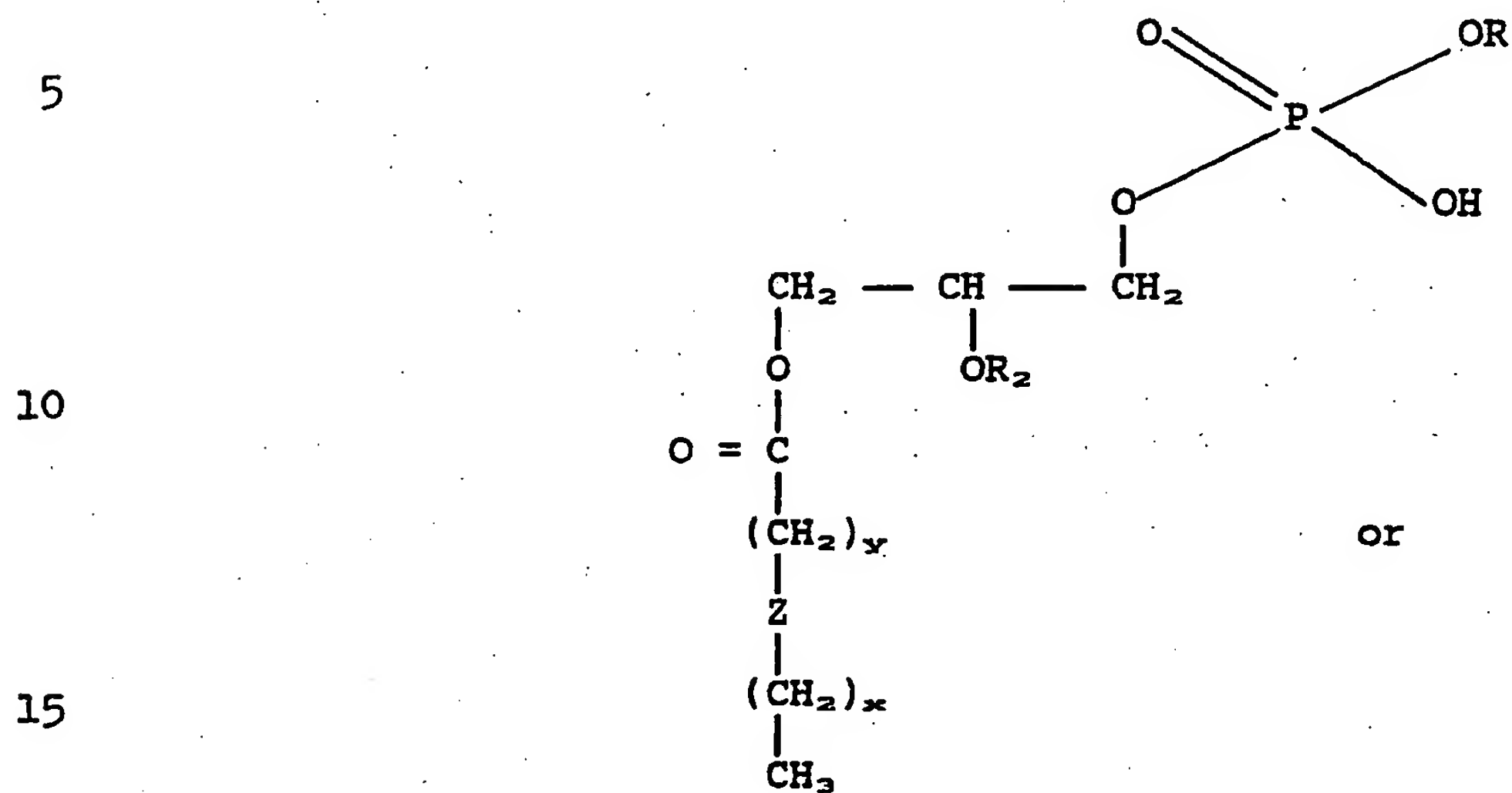
x + y = 11-15 and most preferably 11.

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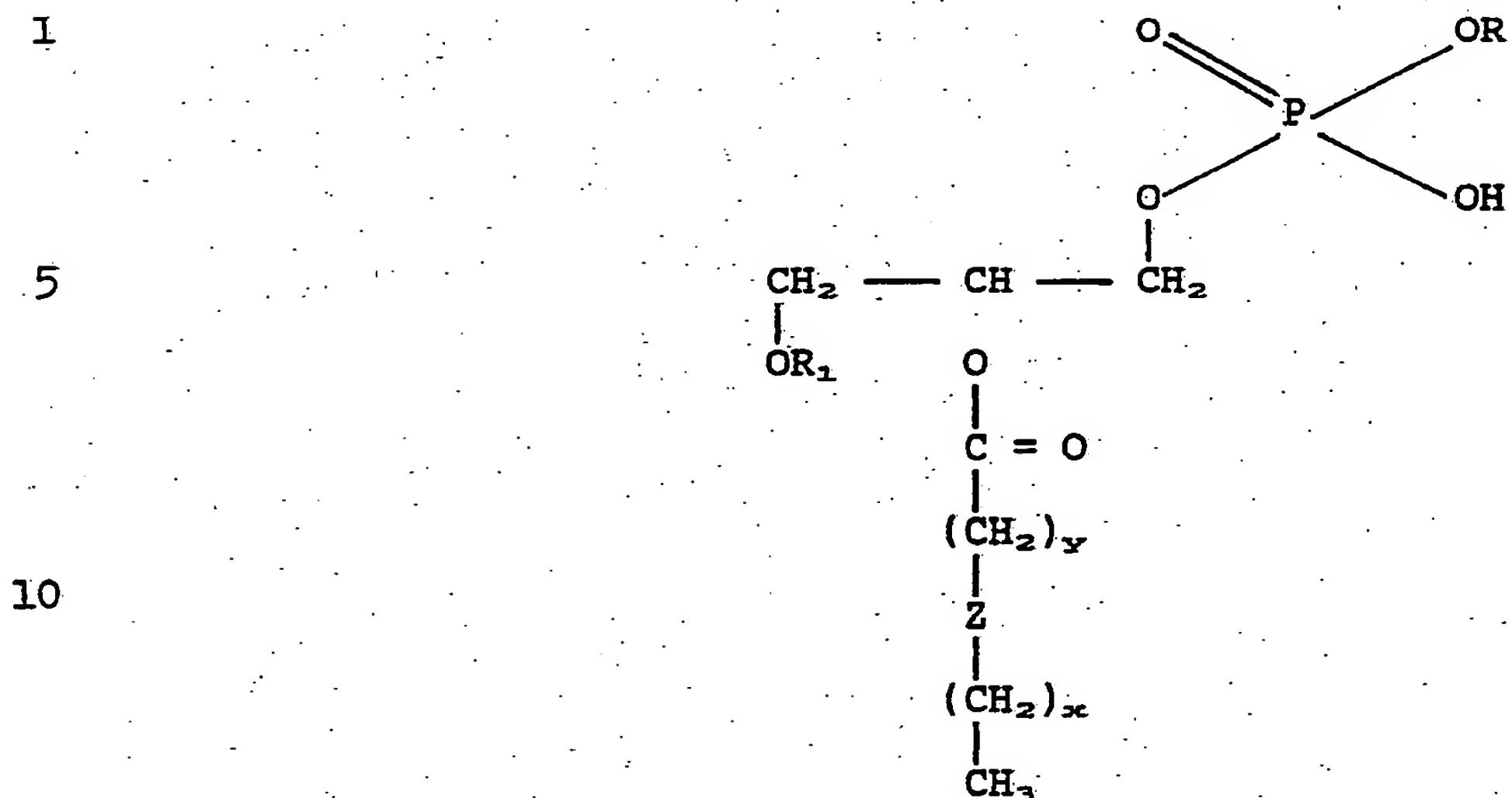
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1 The present invention also contemplates a
phospholipid drug of the formulae:



IX

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IXA

wherein R is as defined hereinabove;

R_2 is hydrogen or alkyl fatty acid acyl group having 4-26 carbon atoms, and more preferably 4-8 or 14 carbon atoms,

Z is oxygen or sulfur;

each x is independently 0-13;

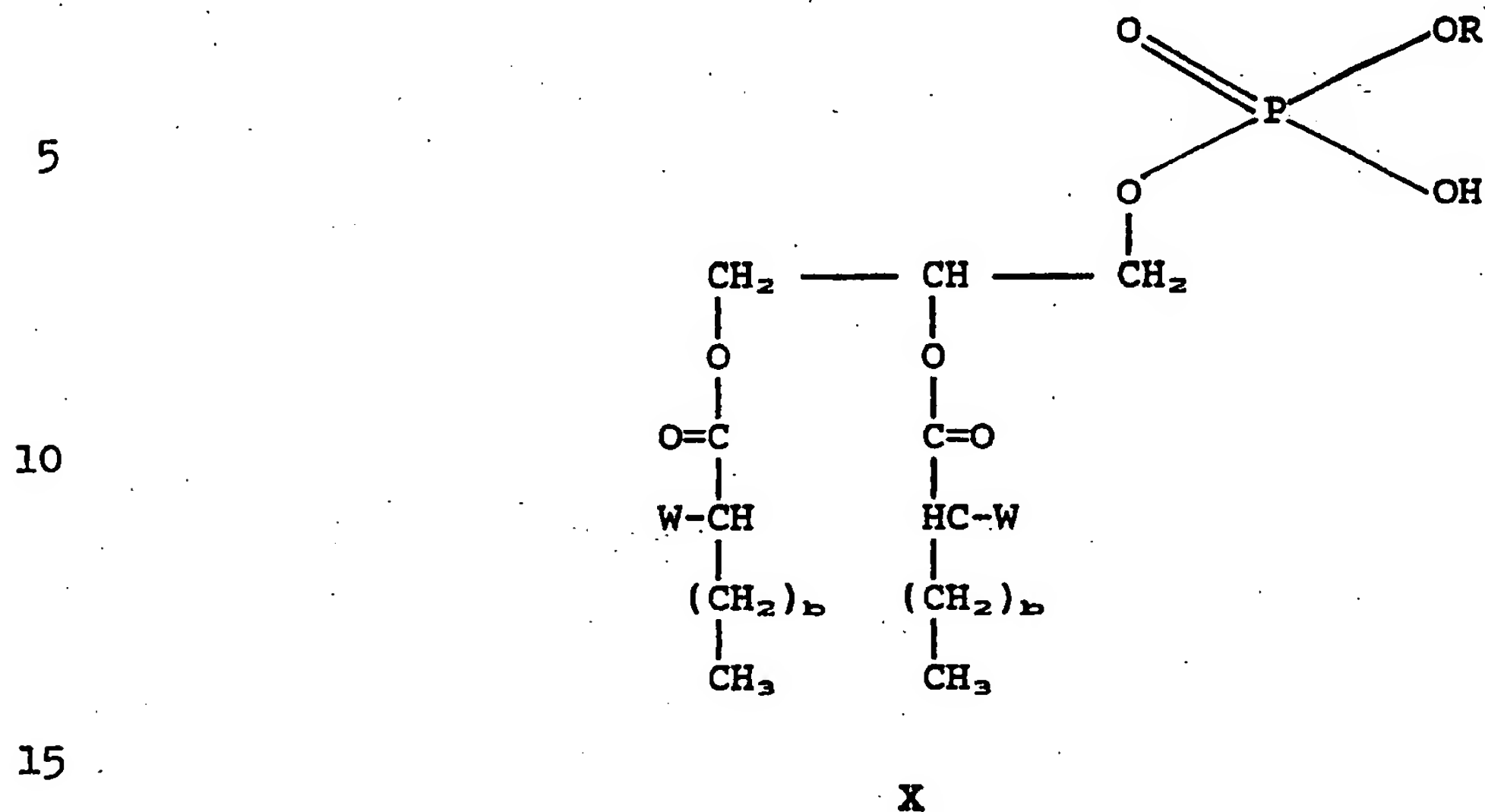
each y is independently 1-13; and

$x + y = 11-13$, and most preferably 11.

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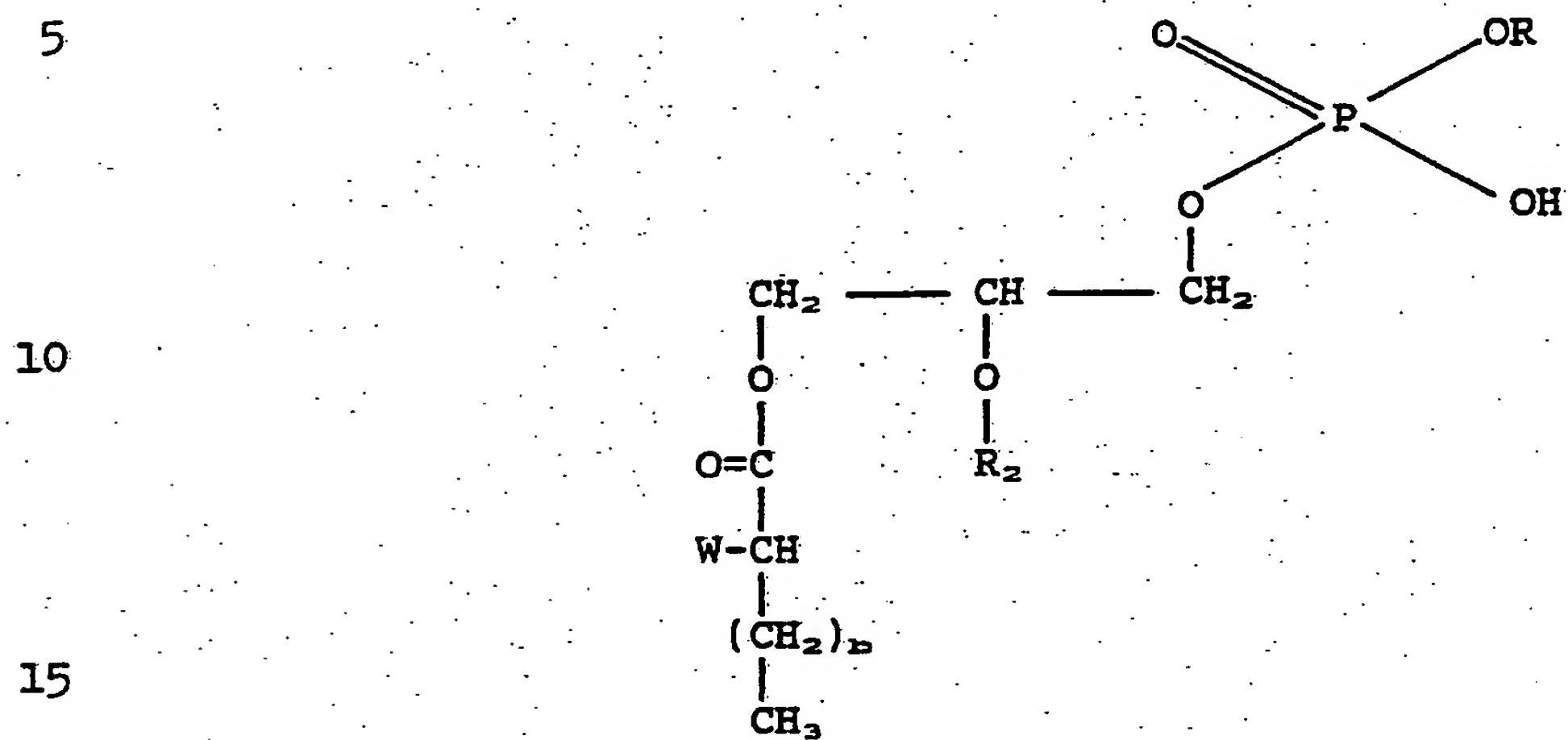
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1 In a further embodiment, the present invention
relates to a phospholipid drug of the formula:



wherein W is halo, hydroxy, alkoxy, mercapto or
alkylthio; and R is as defined hereinabove and
b is 11-13 and most preferably 11.

1 Another preferred embodiment of the present
invention relates to a phospholipid drug of the
formulae:



XI or

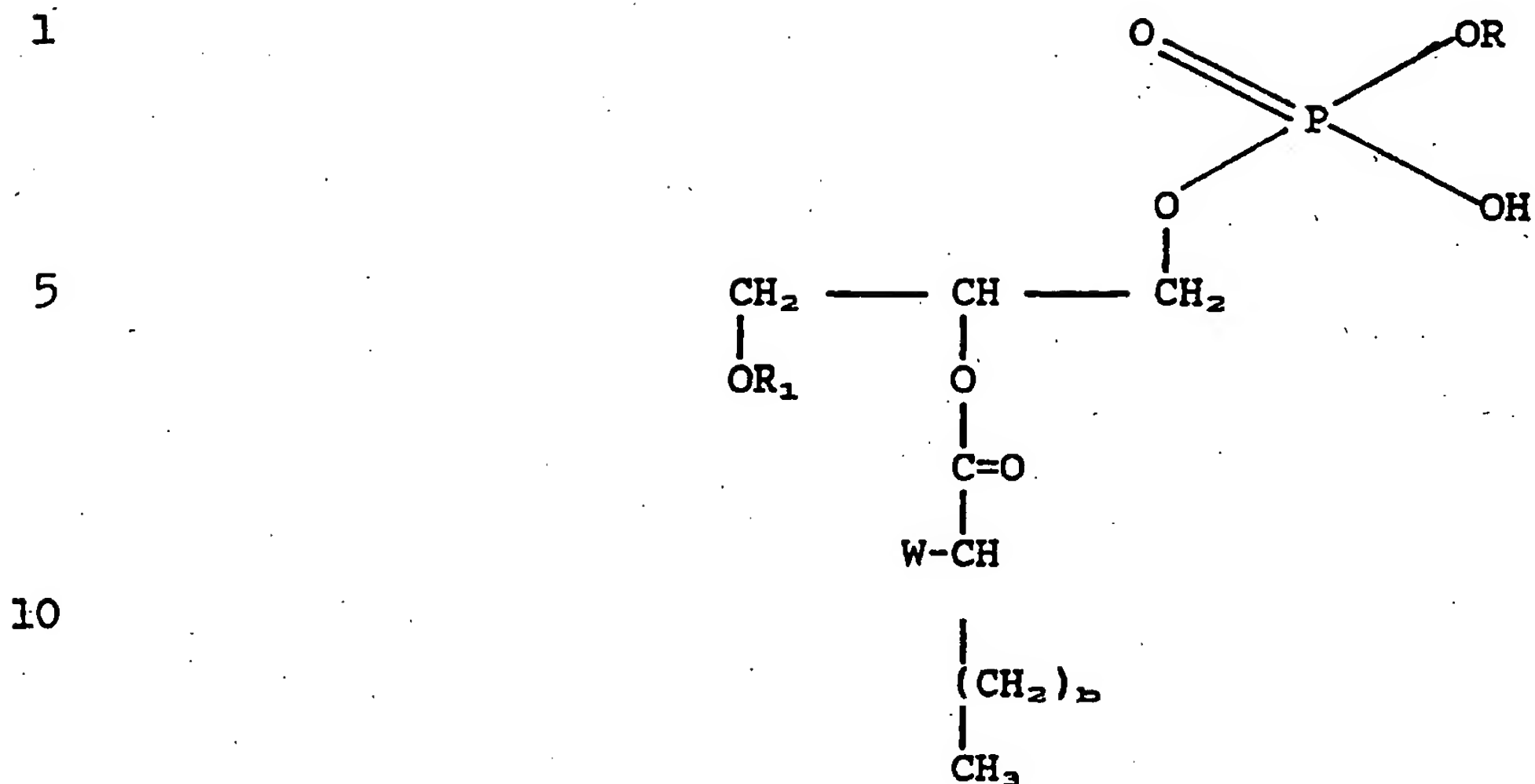
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XII

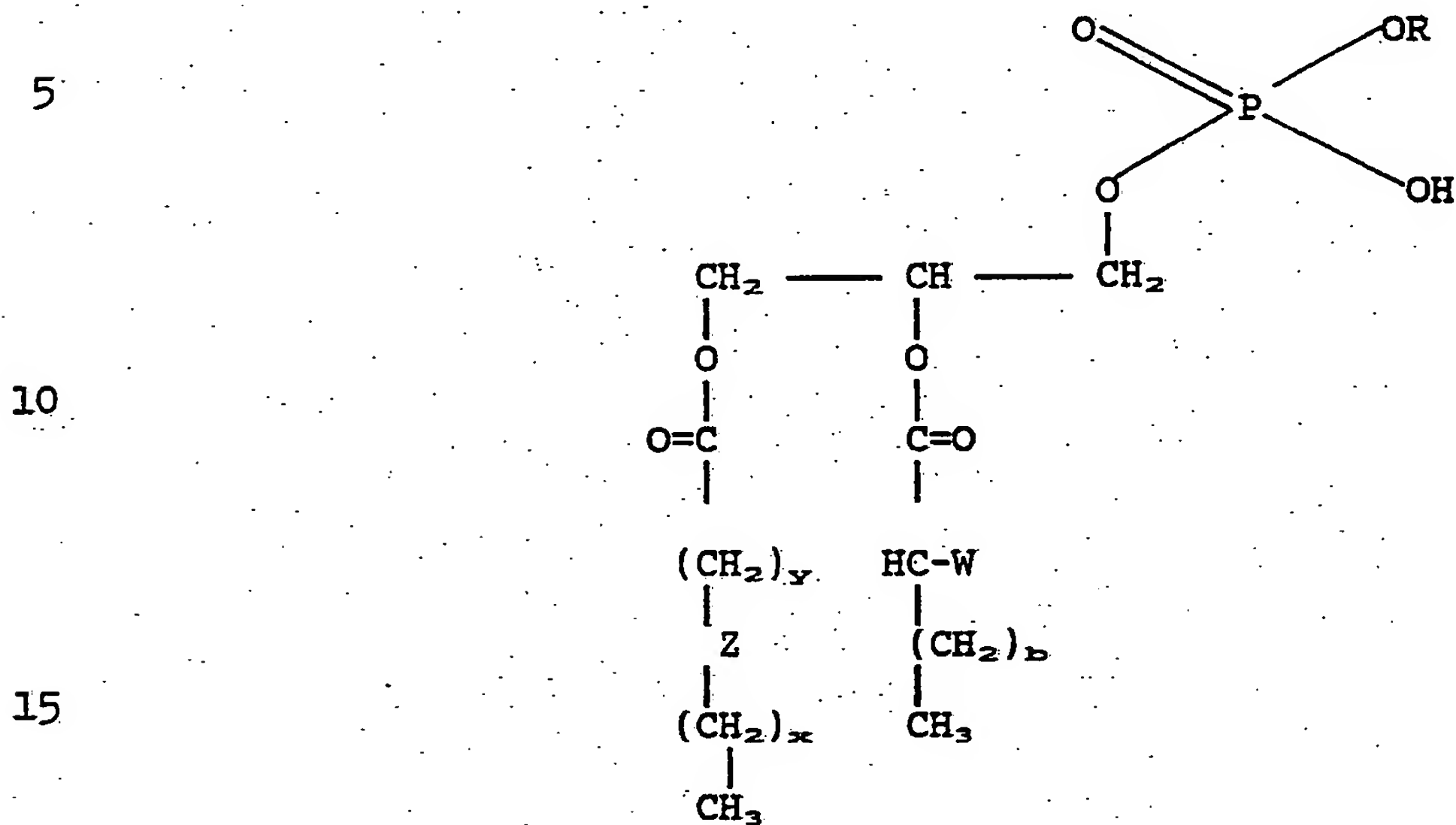
15 wherein R is as defined hereinabove;

R_1 and R_2 are independently hydrogen or alkyl fatty acid acyl group having 4-26 carbon atoms and more preferably 4-8 or 14 carbon atoms,

20 b is 11-13, and most preferably 11

and W is selected from halo, alkoxy, mercapto or alkylthio.

1 In a still further embodiment, the present
invention relates to a phospholipid drug of the formula:



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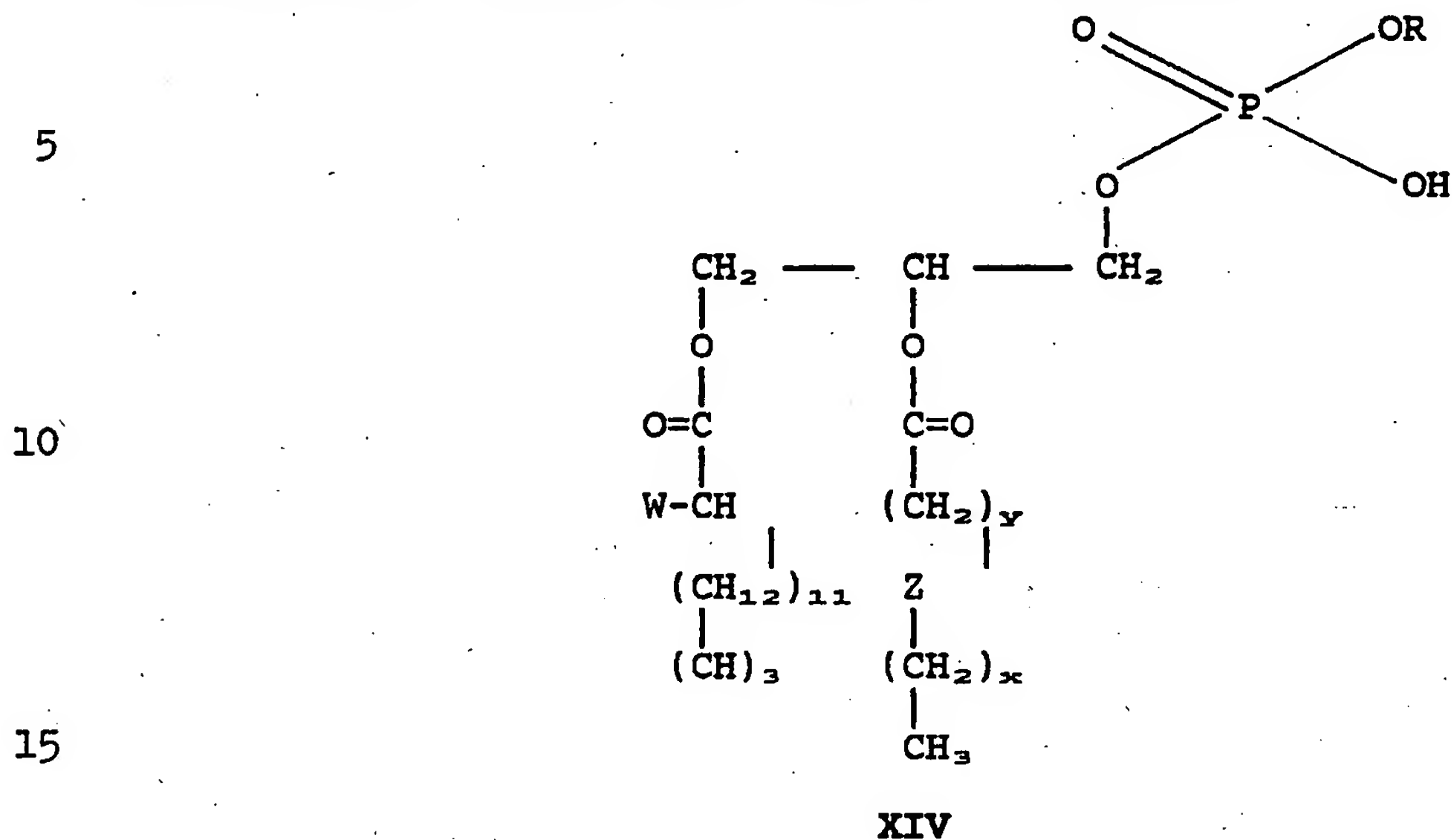
20 wherein R, Z, W, x, y and b are as defined hereinabove.

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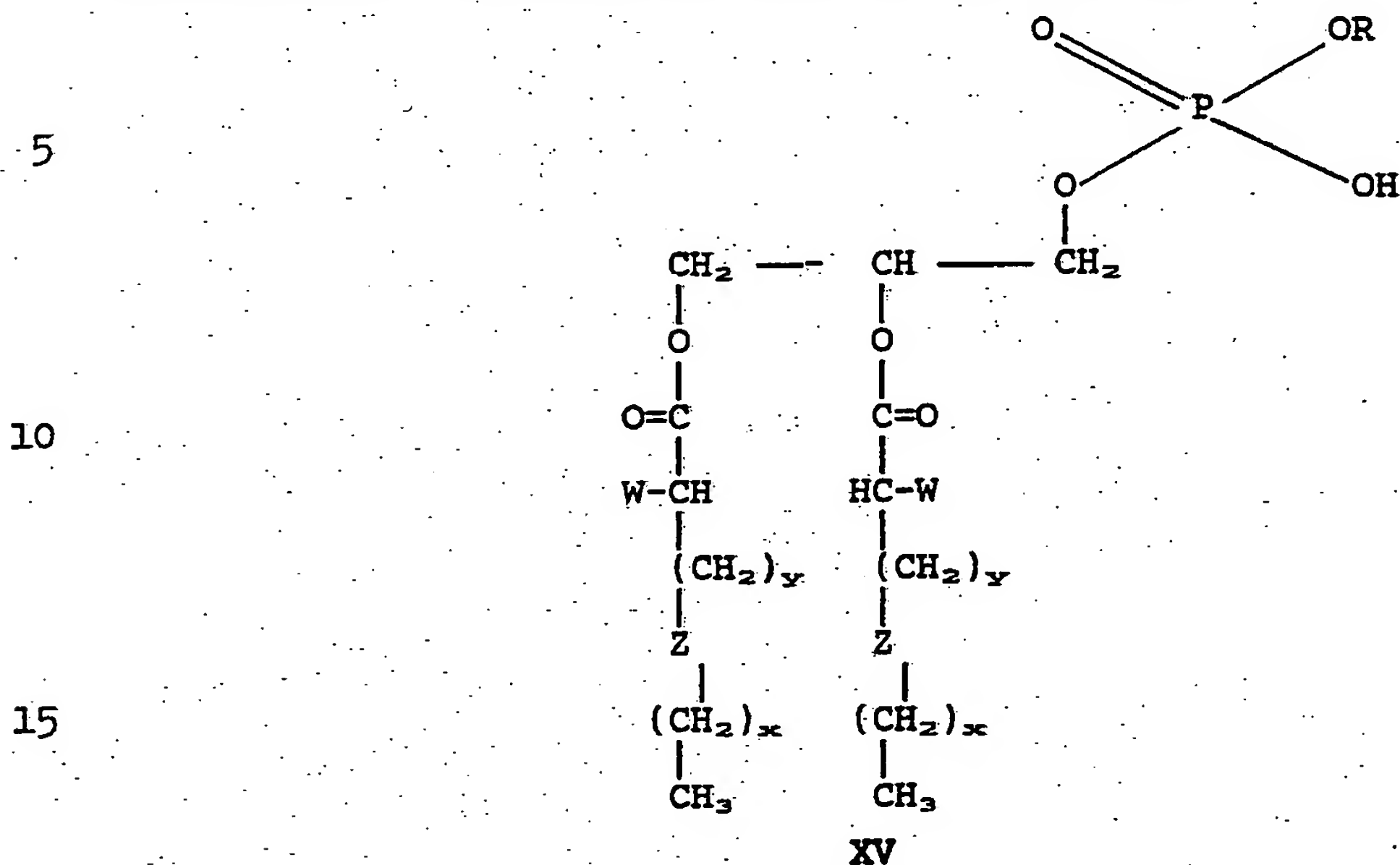
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1 Another embodiment of the present invention
 5 contemplates a phospholipid drug of the formula:



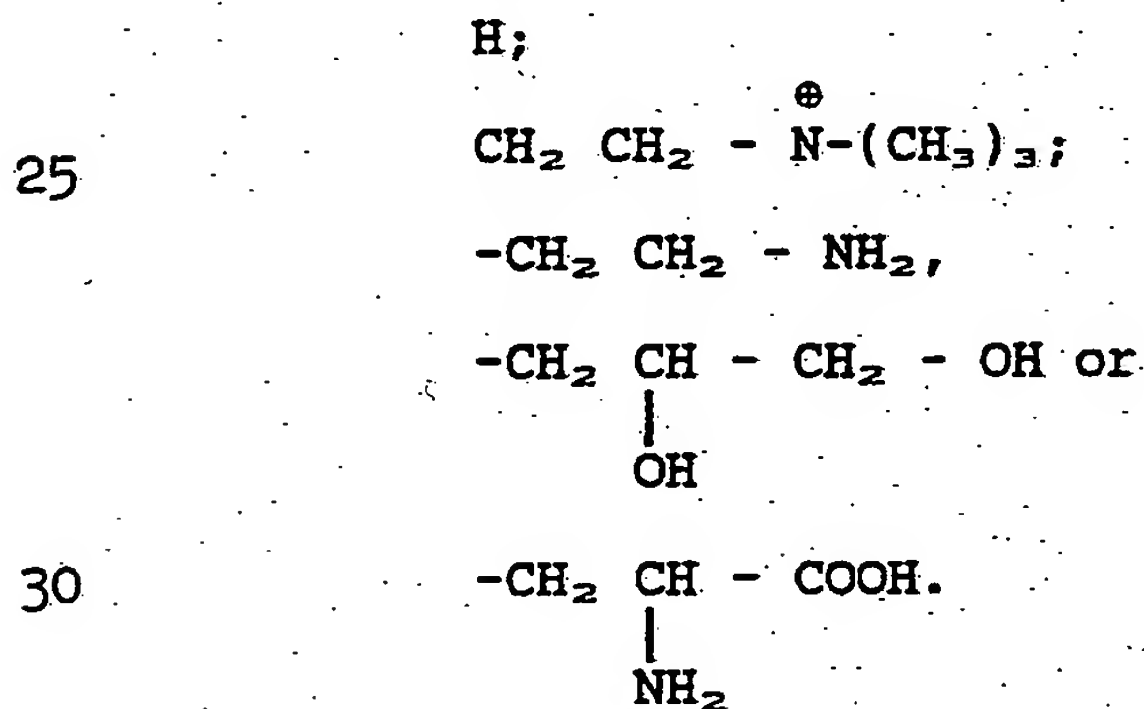
wherein R, Z, W, x and y are as defined hereinabove.

1 In a further embodiment, the present invention
contemplates a phospholipid drug of the formula:

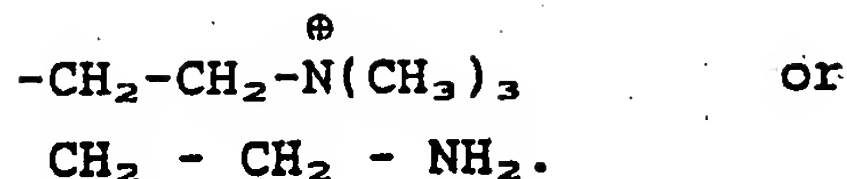


wherein R, Z, W, x, y are each as defined hereinabove.
The compounds described in Formulae VIII to IX also
20 contemplate the basic salts, as defined herein.

In the various embodiments described herein,
it is preferred that R is



1 Preferably, R is

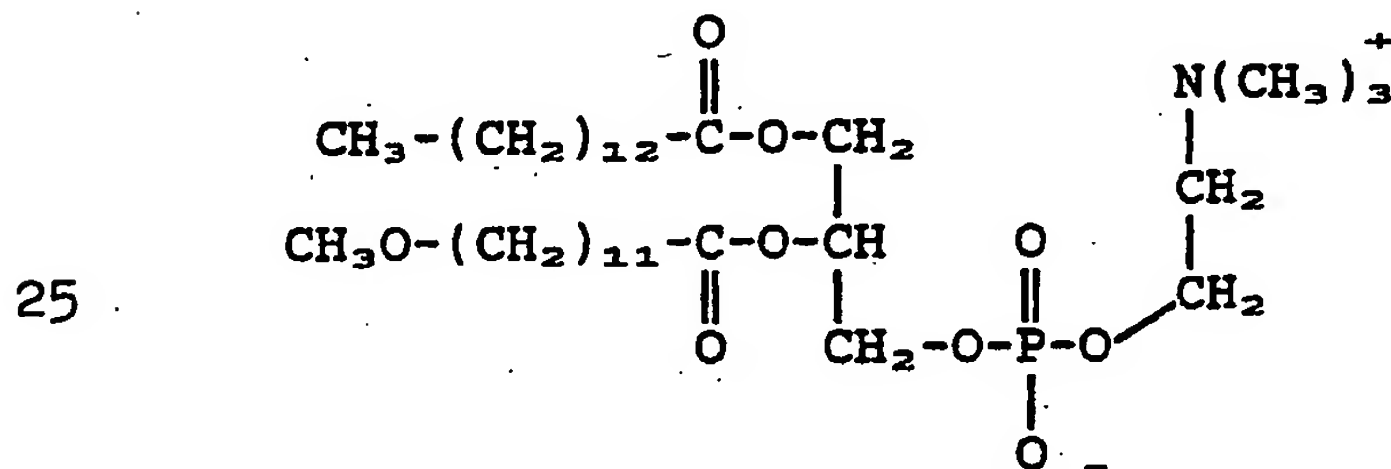


5 In all the embodiments contemplated in Formula VIII-XV hereinabove, it is most preferred that Z is O or S, $x = 0$, $y = 10$ or 11 and W is hydroxy.

In the embodiments described hereinabove, all of the various combinations and permutations of the various variables, R, R₁, R₂, W, Z, x, y, b, etc., wherever possible, is contemplated by the inventors. Furthermore, the present invention encompasses embodiments (compounds, methods, compositions, etc.) which contain one or more elements of each of the Markush groupings in R, R₁, R₂, W, Z, x, y, b, etc. and the various permutations and combinations thereof.

In still another embodiment, the present invention contemplates the compound 1-myristoyl-2-(12-methoxydodecanoyl)-sn-3-phosphatidylcholine (AC1) represented by the formula:

AC1

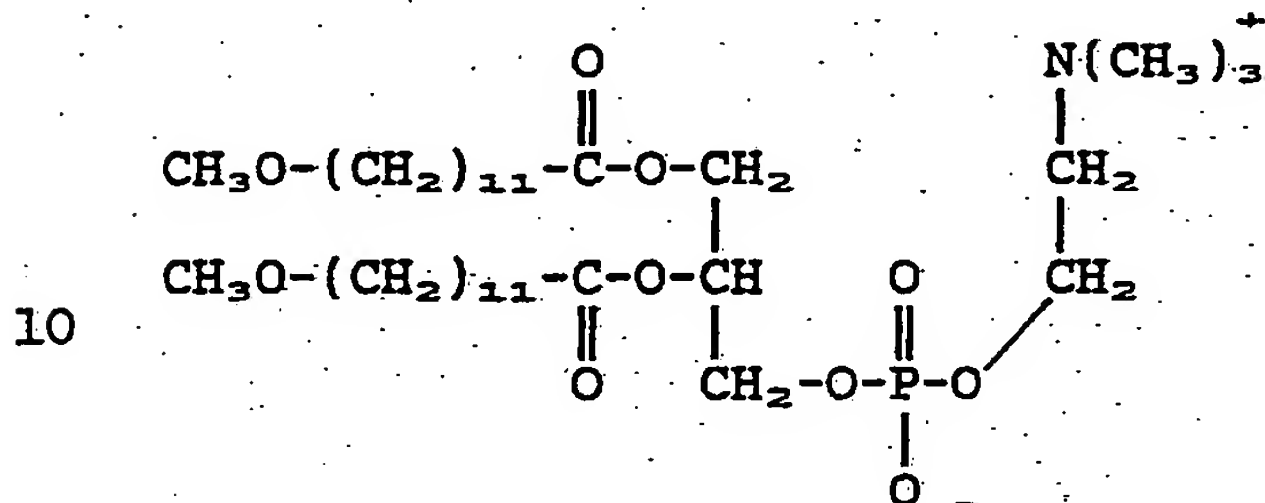


30 As clearly seen, AC1 contains the fatty acid 12MO bonded to the sn-2 position of the glycerol backbone, while a myristoyl group is bonded at the sn-1 position. The present invention contemplates both the L- and D- stereoisomers.

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1 In another embodiment, the present invention contemplates the compound 1,2-(di-12-methoxydodecanoyl)-sn-3-phosphatidylcholine (L-AC2) represented by the formula:

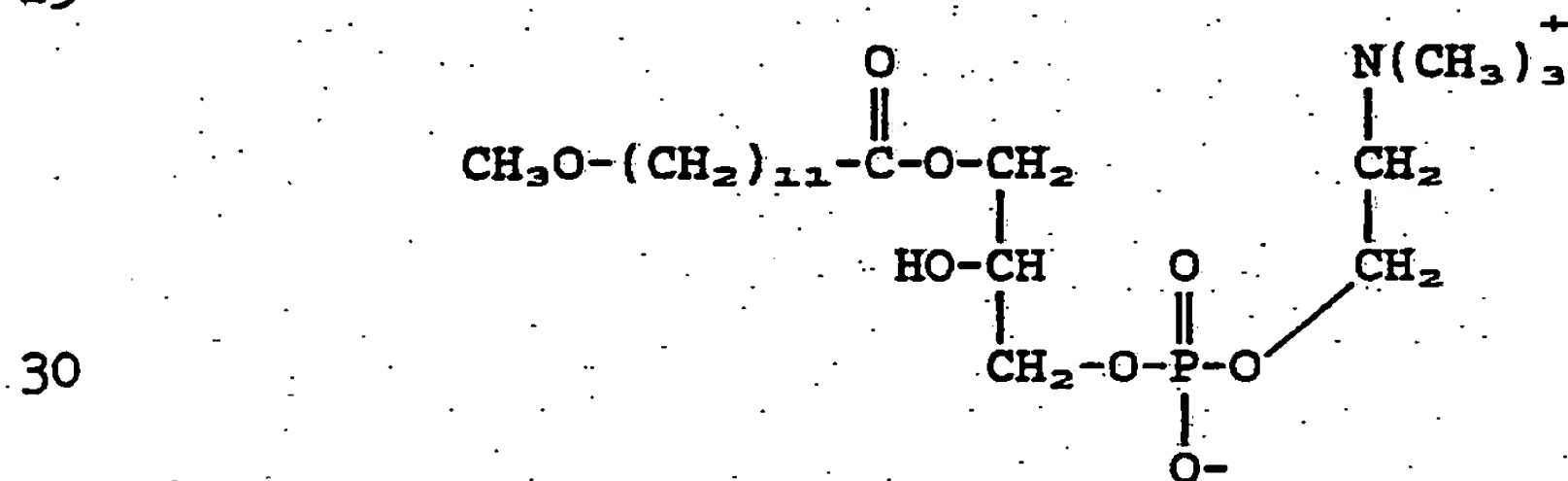
5 AC2



15 Compound AC2 contains the fatty acid 12MO bonded to both the sn-1 and sn-2 positions of the glycerol backbone. Furthermore, the configuration at the sn-2 carbon of the glycerol backbone is in the L configuration.

The present invention also contemplates the D-AC2 molecule, wherein the configuration at the sn-2 carbon of the glycerol backbone is in the D configuration.

In still another embodiment, the present invention contemplates the compound: 1-(12-methoxydodecanoyl)-sn-3-glycerophosphatidylcholine represented by the formula:



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1 hereinafter referred to as the "lysolipid analogs". The
lysolipid analog contains the fatty acid 12MO bonded to
the sn-1 position and hydrogen bonded at the sn-2 posi-
tion of the glycerol backbone. Alternatively, the
5 lysolipid analogs may contain the heteroatom fatty acid,
(e.g., 12MO) bonded to the sn-2 position and the
hydrogen bonded to the sn-1 position. Again, both the
D- and L-stereoisomers contemplated by the present
invention.

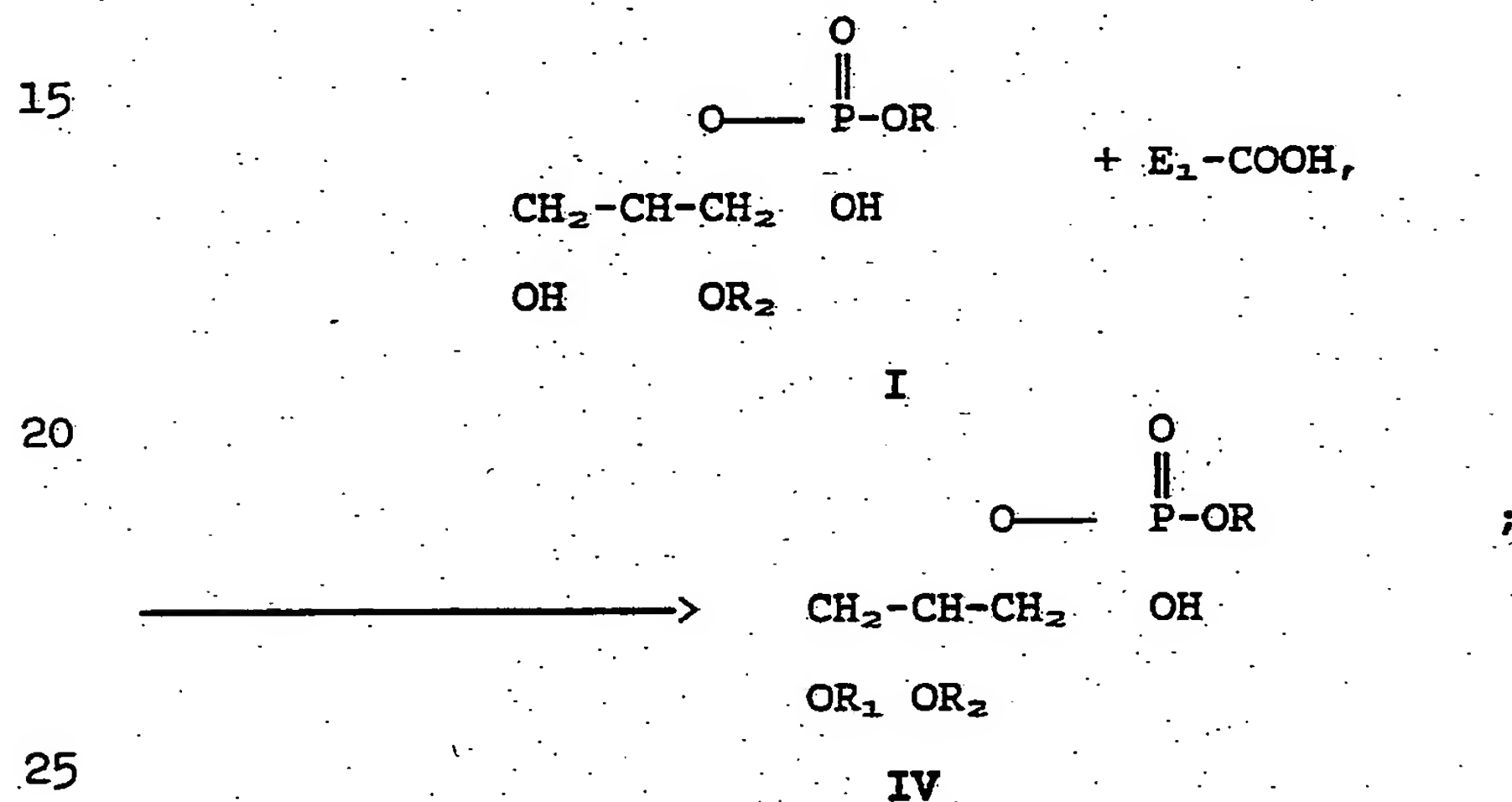
10 Compounds of the present invention can be
prepared in accordance with art- recognized techniques.
Exemplary procedures are described below.

The carboxy group on the heteroatom fatty acid
is activated by standard methods for acylation and is
15 reacted with the hydroxy group on the glycerol backbone
under esterification conditions, known to one skilled in
the art. The reaction may be run in inert solvents that
will dissolve both reagents or it may be run in a
biphasic solvent. Examples include DMSO, crown ethers
20 and the like. The reaction is run at temperatures
facilitating acylation. These temperatures may range
from room temperature to the reflux temperature of the
solvent, although it is preferred that the reaction is
run at about room temperature or slightly above.
25 Furthermore, the reaction may be run under reduced
pressure, such as under vacuum.

Alternatively, the reaction may be run by
first converting the acid to an acylating derivative,
such as the acid halide (e.g., acid chloride, acid
30 bromide) or anhydride, under reaction conditions known
to one skilled in the art. The acylated derivative is
then reacted with the hydroxy group on the glycerol

1 backbone of the glycerol phospholipid under
 esterification conditions as described hereinabove. In
 other words, the reaction may be run in an inert solvent
 that will dissolve both reagents or it may be run in a
 5 two-phase solvent system. The reaction is run at
 temperatures facilitating acylation. These temperatures
 may range from room temperature to the reflux
 temperature of the solvent, although it is preferred
 that the reaction is run at about room temperature or
 10 slightly above. Further, the reaction may be run under
 reduced pressure.

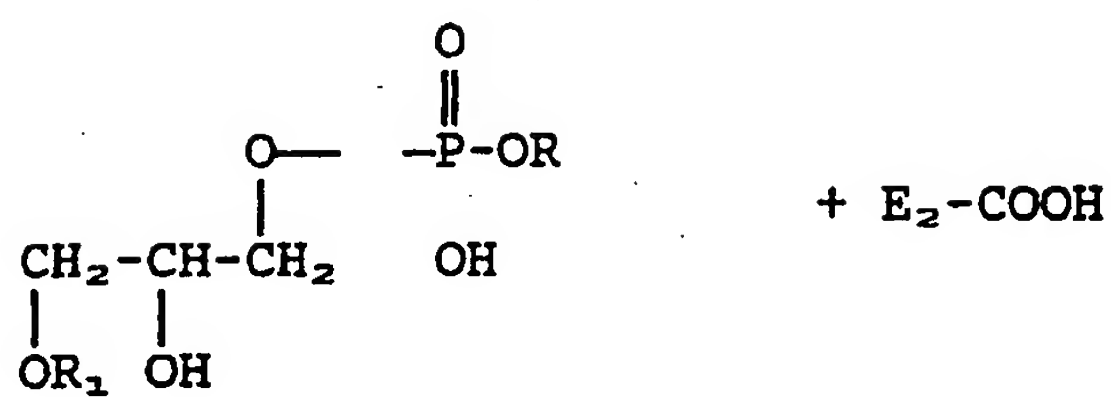
The reactions described hereinabove can be
 schematically represented as follows:



wherein E_1C is R_1 and is a heteroatom fatty acid acyl
 group; E_1COOH is a heteroatom fatty acid

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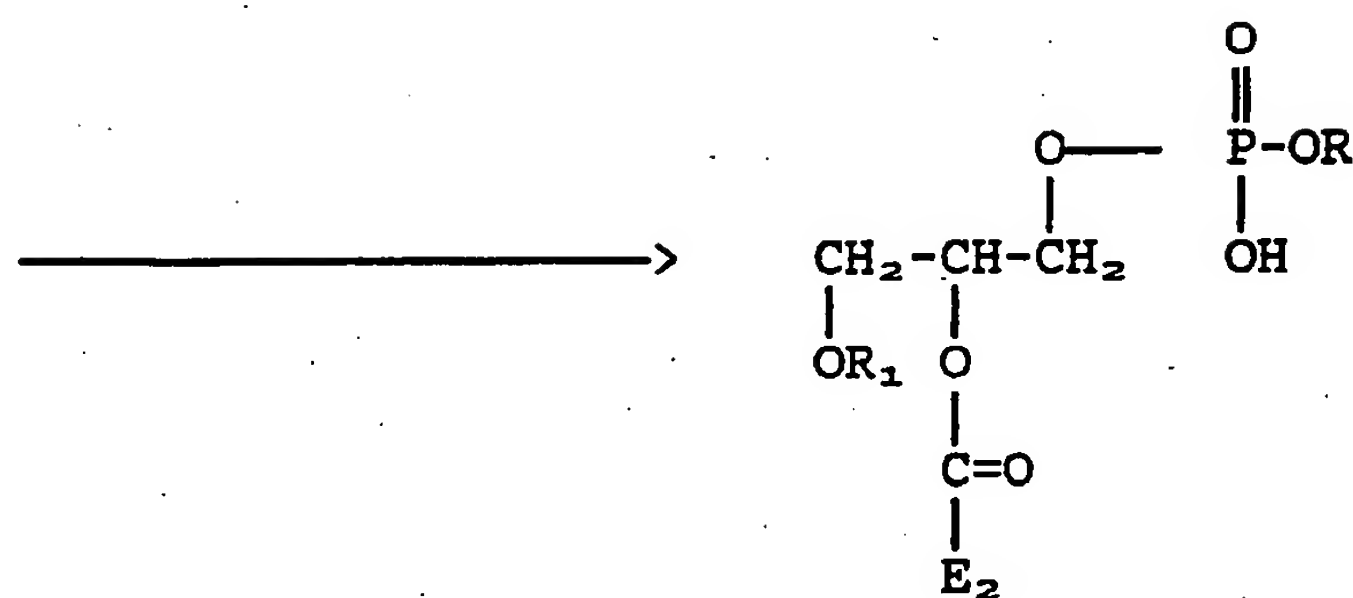
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II

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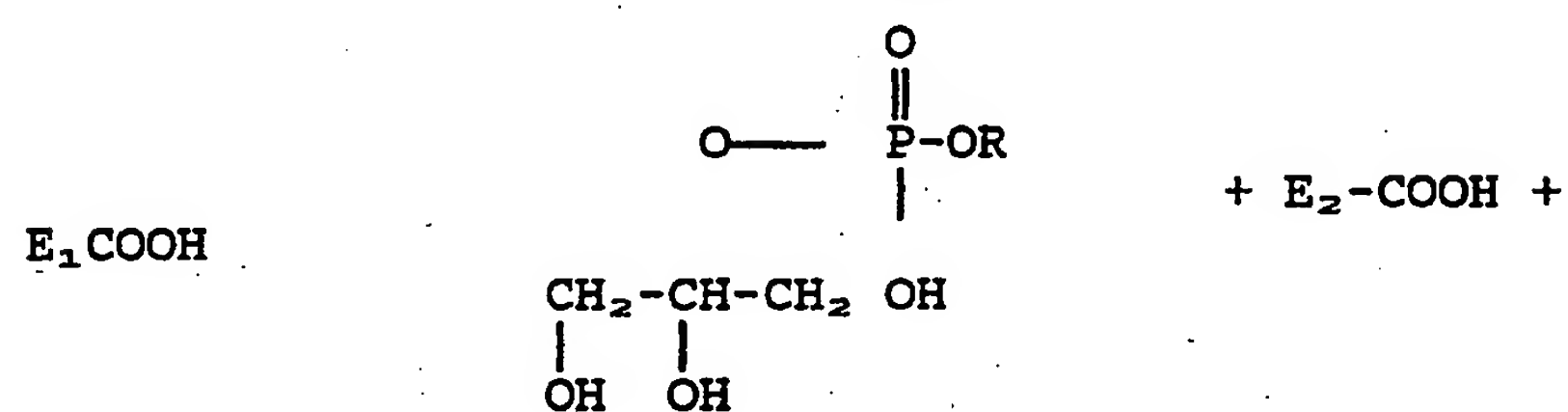


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V

wherein $\text{E}_2\text{C}=\text{O}$ is R_2 and is a heteroatom fatty acid acyl group; and E_2COOH is a heteroatom fatty acid

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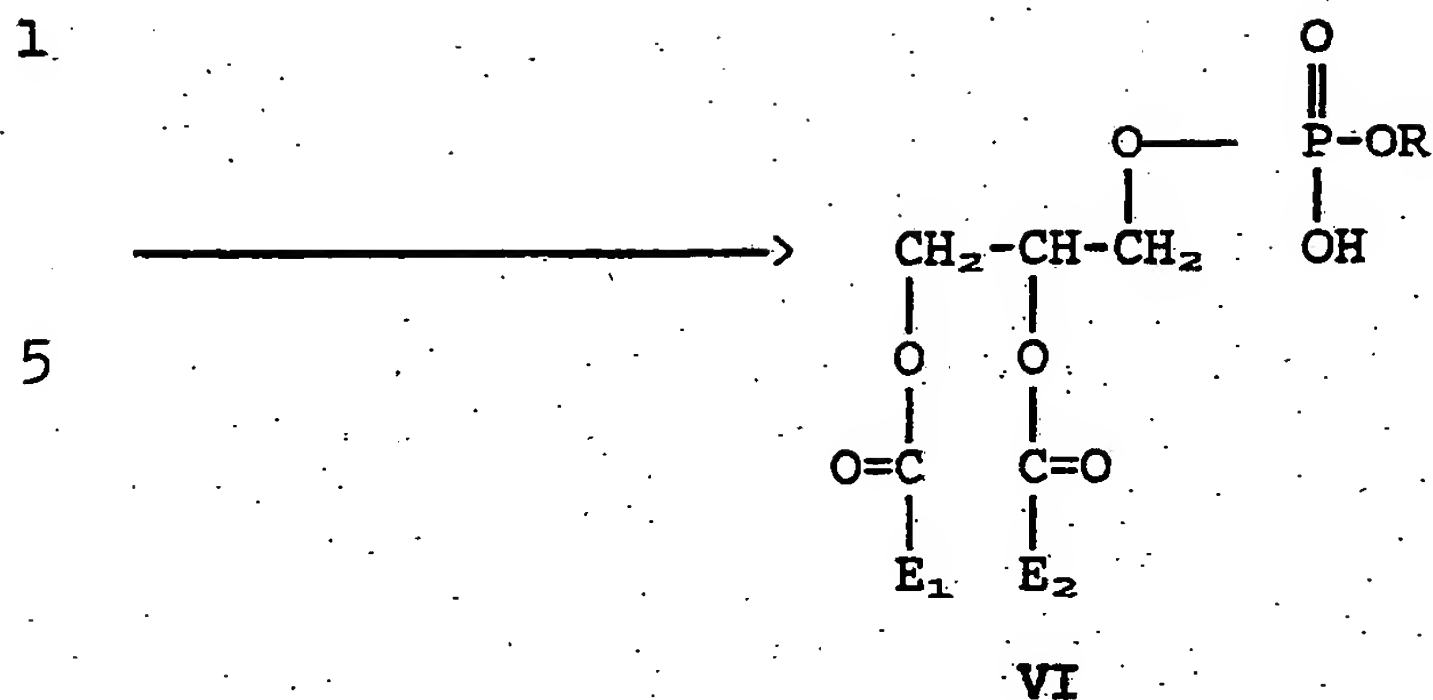
III

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SUBSTITUTE SHEET

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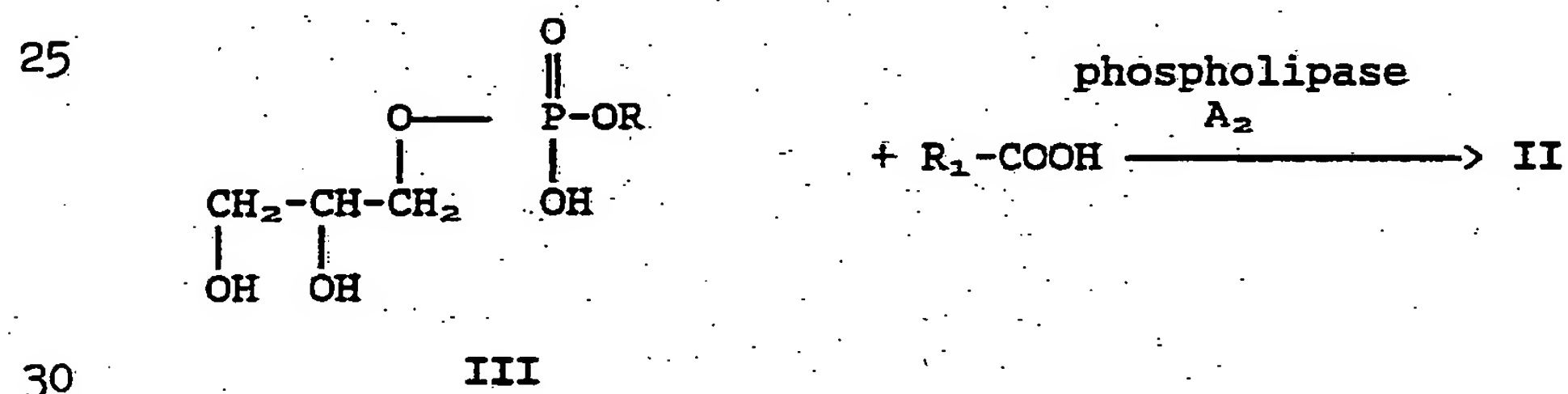
10 wherein $\text{C} - \text{E}_1$ is R_1 and $\text{C} - \text{E}_2$ is R_2 , and $\text{E}_1 \text{ COOH}$

and $\text{E}_2 \text{ COOH}$ are defined hereinabove.

15 In the above schemes, R_1 , R_2 and R are as defined hereinabove and $\text{E}_1 \text{ COOH}$ and $\text{E}_2 \text{ COOH}$ are the heteroatom fatty acids, as defined herein.

Compounds of Formula III are either available commercially or can be prepared by art recognized methods.

20 Compounds of Formula II wherein R_1 is other than hydrogen can be prepared from compounds of Formula III as follows:



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SUBSTITUTE SHEET

1 Acylation of III with an excess of acylating derivative of R_1 -COOH (e.g., the acid halide, anhydride or acid) under esterification conditions will produce the diacylated compounds. The esterification conditions 5 are similar to those described hereinabove. Hydrolysis of the acylated compound with phospholipase A_2 will produce the compound of Formula II.

 Similarly, compounds of Formula I wherein R_2 is other than hydrogen can be prepared from compounds of 10 Formula III as follows:

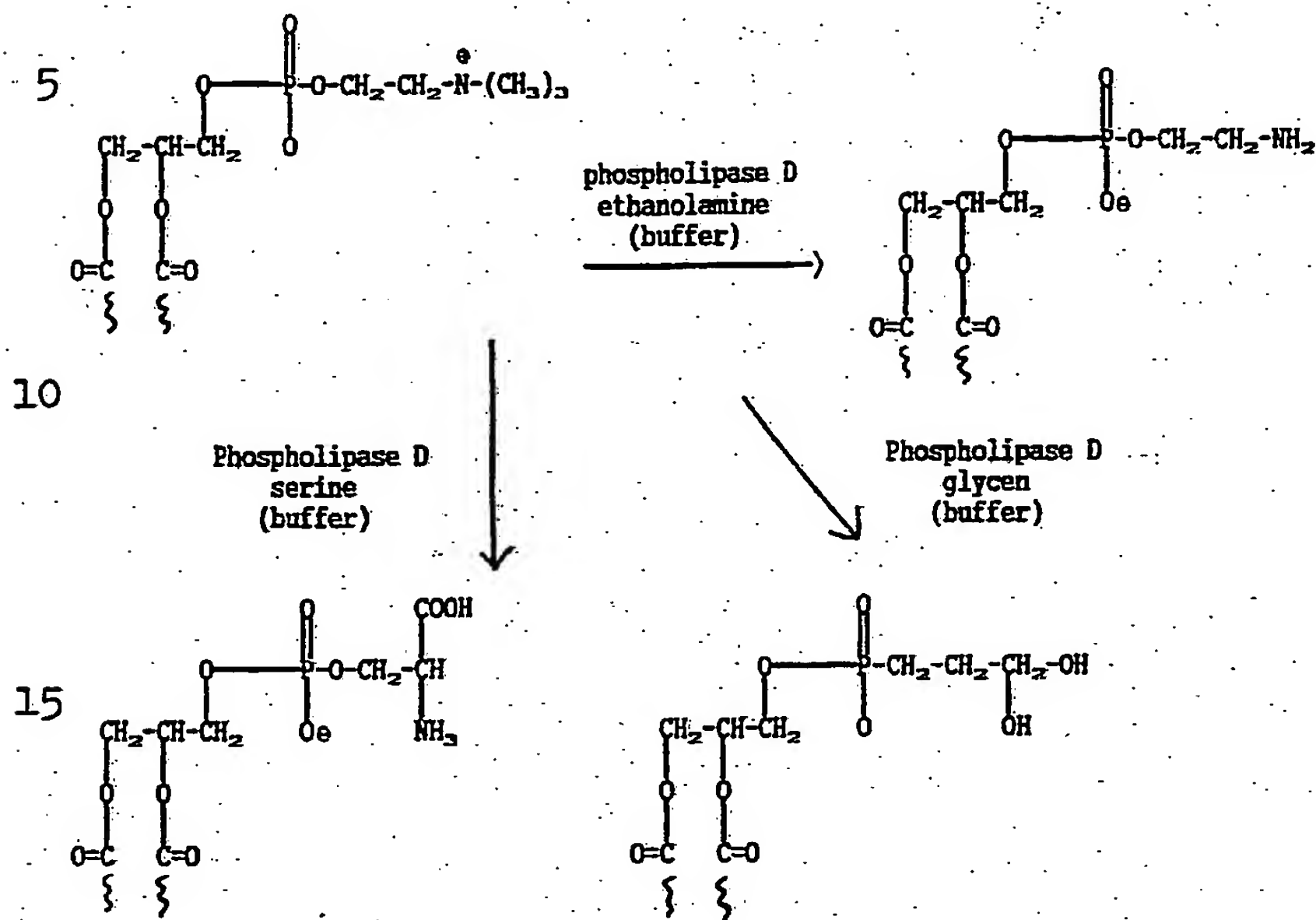


15 Acylating III with an excess of an acylating derivative of E_2 -COOH (e.g., the acid halide, anhydride or acid) under esterification conditions as described hereinabove will produce the diacylated compounds. Hydrolysis of the diacylated compounds with 20 phospholipase A_1 will produce the compound of Formula I.

 In both cases described hereinabove, the acid halide can be prepared from the corresponding acid with thionyl chloride or bromide. Similarly, the anhydride can be prepared from the corresponding acid by reacting 25 the acid with a dehydrating agent, such as P_2O_5 or dicyclohexyl-carbodiimide. Alternatively, the anhydride can be prepared by reacting the acid halide with the corresponding salt of the acid.

 Furthermore, diacylated analogs containing 30 either a glycerol (PG), serine (PS) or ethanolamine (PE) headgroup can be synthesized by transphosphatidylation

1 using phospholipase D treatment of diacylated
phosphatidyl choline analogs, as described hereinbelow.

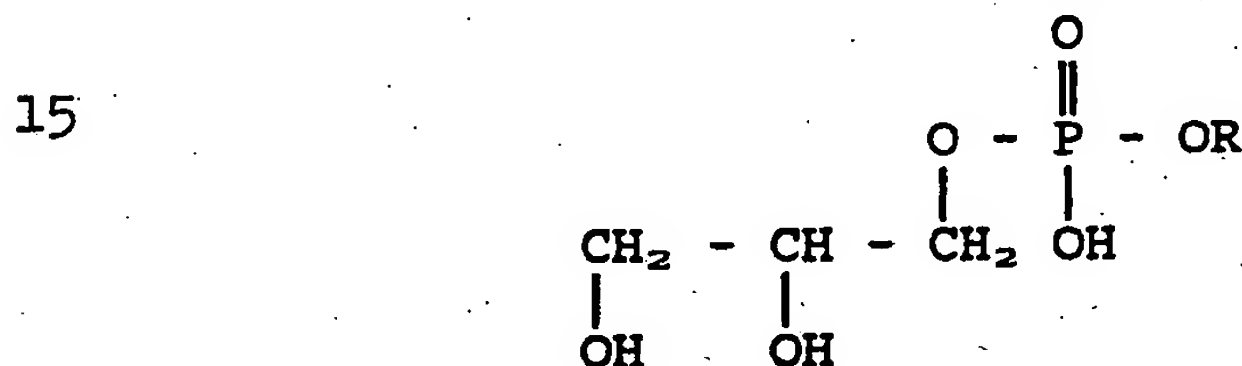


20 wherein represents the remainder of the fatty acid
chain. The transphosphatidylation with phospholipase is
D effective with both the L- and D- stereoisomers of the
glycerophospholipid. Cleavage with phospholipase A₁ or
phospholipase A₂ of the L-isomer will produce the 1-
25 hydroxy or 2-hydroxy analog, respectively.

The acylating derivative of the heteroatom
fatty acid can be prepared in accordance with art-
recognized procedures. For example, the acid chloride
can be prepared by reacting the fatty acid with thionyl
chloride. The anhydride can be prepared by reacting the
30 fatty acid containing a free carboxy group with a
dehydrating agent, such as P₂O₅ or

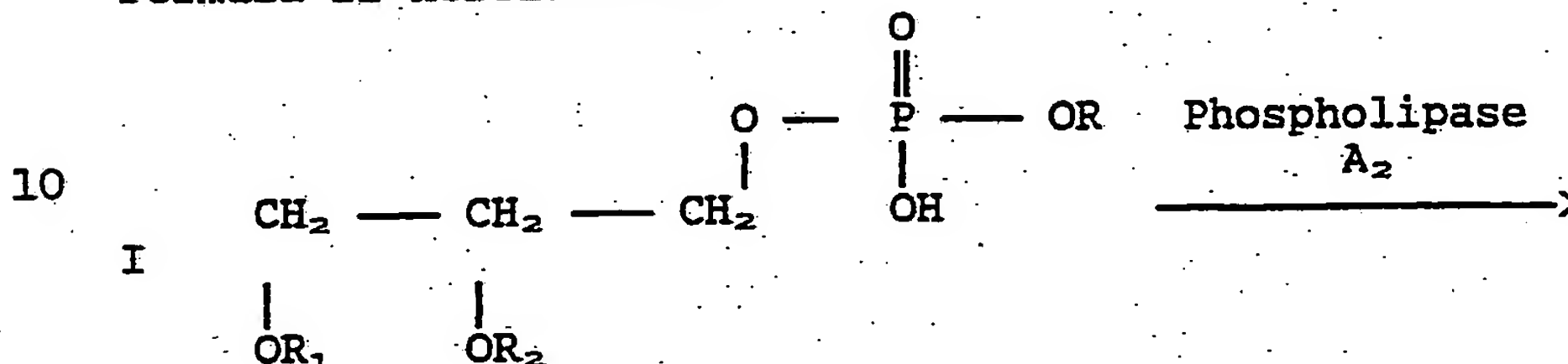
ldicyclohexylcarbodiimide, acetic anhydride, trifluoroacetic anhydride, methoxyacetylene and the like. Alternately, the anhydride can be prepared by treating the acid halide (such as acid chloride) of the fatty acid with the acid salt of the drug.

Alternatively, and especially in the case of the phospholipid drugs of myristic acid derivatives, the phospholipid drug can be prepared using immobilized artificial membranes (IAM), as described in Markovich, et al. in Anal Chem., 1991, 63, 1851-1860, the contents of which are incorporated herein by reference. The procedure will be described in more detail hereinbelow. Generally, the glycerol phospholipid of the formula:



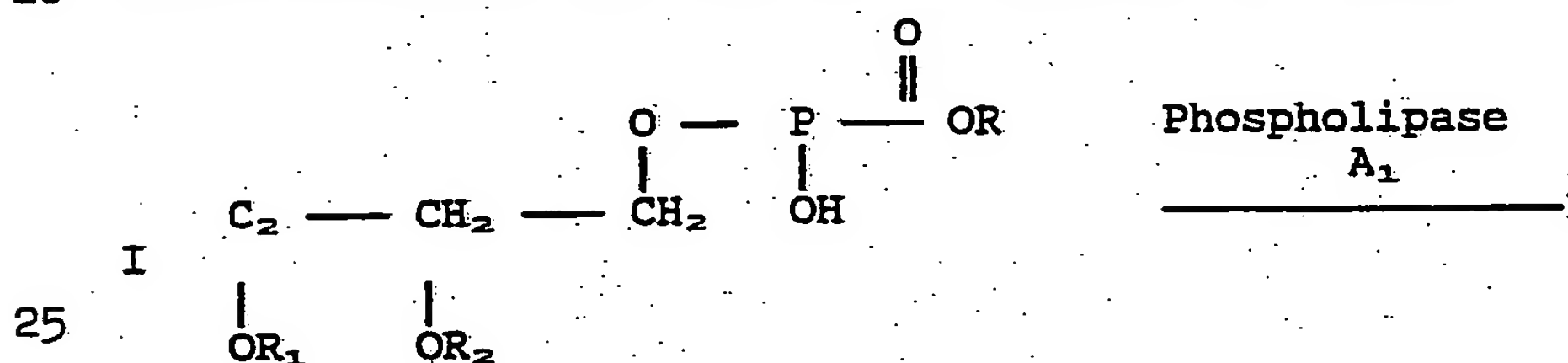
20(hereinafter referred to as GP) wherein R is as defined hereinabove (1 mMol) is solubilized in MeOH (0.5-2.0ml) and is adsorbed onto an IAM packing material, prepared as described hereinbelow by dropwise addition of the methanolic-PC solution. The MeOH was allowed to
 25evaporate after the IAM surface was completely loaded with GP. The IAM/GP solid material was dried overnight in a vacuum at 45°C. After drying, the IAM/GP powdered was suspended in dry chloroform containing the dried acylating derivative of the drug (acid halide,
 30anhydride, and the like) and dried equivalent of a catalyst, such as dimethylaminopyridine and the like.

1 The monoacylated phospholipid compounds of the
 present invention (lyso form) can also be prepared from
 the diacylated phospholipids by using the appropriate
 phospholipase. For example, phospholipase A₂
 5 selectively hydrolyzes the ester at the sn₂ position of
 the glycerol backbone to form a compound having the
 Formula II hereinabove:



15 In the above scheme, R, R₁ and R₂ are as
 defined hereinabove, except that R₁ and R₂ are not
 hydrogen.

Similarly, the other lyso form having Formula
 I can be prepared from the diacylated phospholipid by
 using phospholipase A₁, which selectively hydrolyzes the
 20 ester at the sn₁ position of the glycerol backbone:



A

30 Finally, the compound of Formula IV can be
 prepared by hydrolysis of I with phospholipase A₂,
 hydrolysis of II with phospholipase A₁ or hydrolysis of
 A with phospholipase A₁ and phospholipase A₂ in either

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1 order. It is to be noted that in the above schemes, R,
R₁ and R₂ are as defined hereinabove, except that R₁ and
R₂ are not hydrogen.

5 In the acylation reactions described above, E₁
COOH or E₂ COOH may be unsubstituted or substituted. If
substituted, it is preferred that the substitution is on
the α carbon (the carbon atom adjacent to the carboxy
group). Further, the preferred substituents are
hydroxy, lower alkoxy, mercapto or alkyl thio.

10 These compounds can be prepared from art
recognized techniques. For example, the α -hydroxy
compound can be prepared from the corresponding α -halo
carboxylic acid by reacting the latter with base (OH-)
under substitution reaction conditions. Furthermore,
15 the mercapto compound can be prepared from the
corresponding α -halo carboxylic acid by reacting the
latter compound with HS⁻ under substitution reaction
conditions, while the α -alkylthio carboxylic acid can be
prepared from the corresponding α -halo carboxylic acid
20 by reacting the latter with lower alkylthiolate under
substitution reaction conditions. The α -lower alkoxy
derivative can be prepared by reacting the α -halo
carboxylic acid with lower alkoxide under Williamson
reaction conditions.

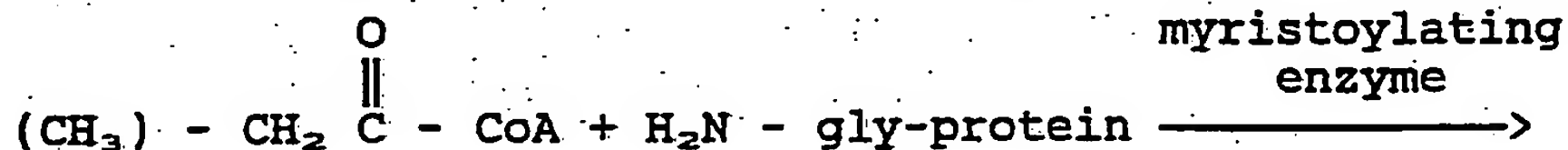
25 The α -halo carboxylic acid can be prepared by
reacting E₁ COOH (or E₂ COOH) with phosphorous and
halogen (preferably Cl₂ or Br₂) or phosphorus trihalide
under Hell-Volhard-Zelinsky reaction condition as
described hereinbelow on Pages 53-54. Alternatively,
30 the α -halo carboxylic acid can be prepared from the
malonic acid ester synthesis described hereinbelow.

1 It is to be understood that in some of the
 reactions described hereinabove, it may be necessary to
 employ protecting groups on reactive functional groups,
 such as hydroxy, that may be present. The protecting
 5 groups to be employed are obvious to one skilled in the
 art. Examples of various protecting groups can be found
 in "Protective Groups in Organic Synthesis" by T.W.
 Green, John Wiley and Son, 1981, which is incorporated
 herein by reference.

10 In the reactions described hereinabove, the
 various products can be separated and purified by art
 recognized techniques known to one skilled in the art,
 such as flash chromatography or HPLC.

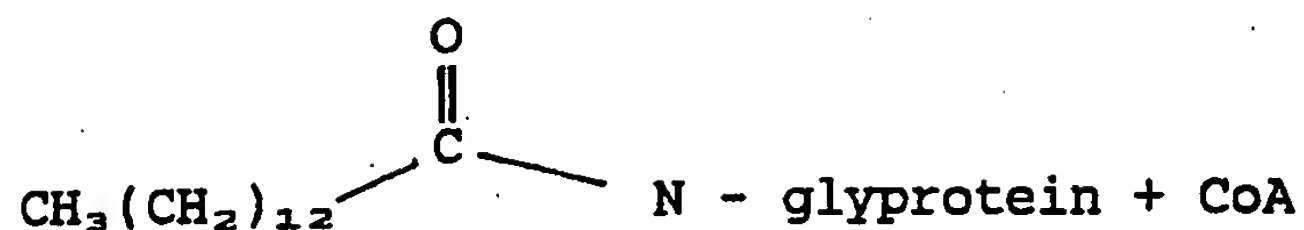
The phospholipid compounds resulting from the
 15 above reactions are used to treat diseases caused by
 retroviruses, such as AIDS and ARCS in animals,
 especially mammals, by administering to said animal an
 effective amount of the compound to treat said diseased
 state. The present invention is directed to those
 20 compounds as well as the use of the compounds in
 treating diseases caused by retroviruses. Without
 wishing to be bound, it is believed that the compounds
 of the present invention interfere with protein
 myristoylation, a reaction which is necessary for HIV
 25 infections.

The HIV-1 genome encodes for two myristoylated
 proteins: p^{17gag} and p^{27nec}. In situ myristoylation of
 these proteins is critical for the establishment and
 maintenance of HIV infection. The myristoylation
 30 reaction can be represented as follows:



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N-myristoyltransferase (NMT) is the enzyme that cotranslationally transfers the myristoyl group to endogenous cellular and viral proteins. It is believed that the compounds of the present invention exhibit inhibitory activity against viruses that produce myristoylated proteins.

10

Interference with protein myristoylation has been a drug target site for inhibiting HIV replication. It has been reported that heteroatom analogs of myristic acid containing oxygen or sulfur substituted for alkyl methylene groups exhibit activity against HIV replication in infected cells. European Patent Application 415,902 alleges that oxy and thio substituted fatty acid analog substrates of myristoylating enzymes in which a methylene group at carbon position 4 to 13 is replaced by an oxygen or sulfur can be used to treat retroviral infections. It has also been reported that metabolic activation of 2-substituted derivatives of myristic acid inhibits myristoyl CoA: Protein N-myristoyltransferase. See Paige, et al., Biochemistry 1990, 29, 10566-10573.

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However, the present inventors have discovered that the efficacy of these compounds have been significantly enhanced by acylating these molecules to the glycerol backbone of a phospholipid in accordance with the present invention, thus generating new phospholipid drugs. More particularly, the fatty acid analogs of myristic acid are acylated to one or both of

1 the hydroxy groups of the glycerophospholipid, i.e. the
non-polar end. The acylation at the non-polar end of
the phospholipid significantly influences the ability to
inhibit HIV replication in macrophages and T cells and
5 also alters the toxicity of the fatty acid analogs.
Additionally, these acylated phospholipids may be
sensitive to phospholipases A1 and A2, thereby providing
a specific cleavage mechanism for the acyl group(s)
containing the biologically active fatty acids, once the
10 product is transported into the cell.

The present compounds can be formulated with
suitable pharmaceutically acceptable carriers into unit
dosage form and can be administered orally,
transdermally parenterally or rectally. The active
15 compound may be orally administered, for example, with
an inert diluent or with an assimilable edible carrier,
or it may be enclosed in hard or soft shell gelatin
capsule, or it may be compressed into tablets, or it may
be incorporated directly with the food of the diet. For
20 oral therapeutic administration, the active compound may
be incorporated with excipients and used in the form of
ingestible tablets, buccal tablets, troches, capsules,
elixirs, suspensions, syrups, wafers and the like. Such
compositions and preparations should contain at least 1%
25 of active compound. The percentage of the compositions
and preparations may, of course, be varied and may
conveniently be between about 5 to about 80% of the
weight of the unit. The amount of active compound in
such therapeutically useful compositions is such that a
30 suitable dosage will be obtained. Preferred composi-
tions or preparations according to the present invention
are prepared so that an oral dosage unit form contains a

1 pharmaceutically effective amount which can be
determined by the physician. For example, the oral
dosage unit form may contain between about 0.5 and 1000
mg of active compound.

5 The tablets, troches, pills, capsules and the
like may also contain the following: A binder such as
gum tragacanth, acacia, corn starch or gelatin;
excipients such as dicalcium phosphate; a disintegrating
agent such as corn starch, potato starch, alginic acid
10 and the like; a lubricant such as magnesium stearate;
and a sweetening agent such as sucrose, lactose or
saccharin may be added or a flavoring agent such a
peppermint, oil of wintergreen or cherry flavoring.
When the dosage unit form is a capsule, it may contain,
15 in addition to materials of the above type, a liquid
carrier. Various other materials may be present as
coatings or to otherwise modify the physical form of the
dosage unit. For instance, tablets, pills or capsules
may be coated with shellac, sugar or both. A syrup or
20 elixir may contain the active compound, sucrose as a
sweetening agent, methyl and propylparabens as
preservatives, a dye and flavoring such as cherry or
orange flavor. Of course, any material used in
preparing any dosage unit form should be
25 pharmaceutically pure and substantially non-toxic in the
amounts employed. In addition, the active compound may
be incorporated into sustained-release preparations and
formulations.

 The active compound may also be administered
30 parenterally or intraperitoneally. Dispersions can also
be prepared in glycerol, liquid polyethylene glycols,
and mixtures thereof and in oils. Under ordinary

1 conditions of storage and use, these preparations
contain a preservative to prevent the growth of
microorganisms.

5 The pharmaceutical forms suitable for
injectable use include sterile aqueous solutions (where
water soluble) or dispersions and sterile powders for
the extemporaneous preparation of sterile injectable
solutions or dispersions. In all cases the form must be
sterile and must be fluid to the extent that easy
10 syringability exists. It must be stable under the
conditions of manufacture and storage and must be
preserved against the contaminating action of
microorganisms such as bacteria and fungi. The carrier
can be a solvent or dispersion medium containing, for
15 example, water, ethanol, polyol (for example, glycerol,
propylene, glycol, and liquid polyethylene glycol and
the like), suitable mixtures thereof, and vegetable
oils. The proper fluidity can be maintained, for
example, by the use of a coating such as lecithin, by
20 the maintenance of the required particle size in the
case of dispersion and by the use of surfactants. The
prevention of the action of microorganisms can be
brought about by various antibacterial and antifungal
agents, for example, parabens, chlorobutanol, phenol,
25 sorbic acid, thimerosal and the like. In many cases, it
will be preferable to include isotonic agents, for
example, sugars or sodium chloride. Prolonged
absorption of the injectable compositions can be brought
about by the use in the compositions of agents delaying
30 absorption, for example, aluminum monostearate and
gelatin.

1 Sterile injectable solutions are prepared by
incorporating the active compound in the required amount
in the appropriate solvent with various of the other
ingredients enumerated above, as required, followed by
5 filtered sterilization. Generally, dispersions are
prepared by incorporating the various sterilized active
ingredient into a sterile vehicle which contains the
basic dispersion medium and the required other
ingredients from those enumerated above. In the case of
10 sterile powders for the preparation of sterile in-
jectable solutions, the preferred methods of preparation
are vacuum drying and the freeze-drying technique which
yield a powder of the active ingredient plus any
additional desired ingredient from previously sterile-
15 filtered solution thereof.

As used herein, "pharmaceutically acceptable
carrier" includes any and all solvents, dispersion
media, coatings, antibacterial and antifungal agents,
isotonic and absorption delaying agents and the like.
20 The use of such media and agents for pharmaceutical
active substances is well known in the art. Except
insofar as any conventional media or agent is
incompatible with the active ingredient, its use in the
therapeutic compositions is contemplated. Supplementary
25 active ingredients can also be incorporated into the
compositions.

It is especially advantageous to formulate
parenteral compositions in unit dosage form for ease of
administration and uniformity of dosage unit. Dosage
30 form as used herein refers to physically discrete units
suited as unitary dosages for the mammalian subjects to
be treated; each unit containing a predetermined

1 quantity of active material calculated to produce the
desired therapeutic effect in association with the
required pharmaceutical carrier. The specification for
the novel dosage unit forms of the invention are
5 dictated by and directly dependent on (a) the unique
characteristics of the active material and the
particular therapeutic effect to be achieved, and (b)
the limitations inherent in the art of compounding such
an active material for the treatment of disease in
10 living subjects having a diseased condition in which
bodily health is impaired as herein disclosed in detail.

The principal active ingredient is compounded
for convenient and effective administration in effective
amounts with a suitable pharmaceutically acceptable
15 carrier in dosage unit form as hereinbefore disclosed.
The physician can determine the amount of drug to be
utilized. A unit dosage form can, for example, contain
the principal active compound in amounts ranging from
about 0.5 to about 1000 mg. In the case of compositions
20 containing supplementary active ingredients, the dosages
are determined by reference to the usual dose and manner
of administration of the said ingredients.

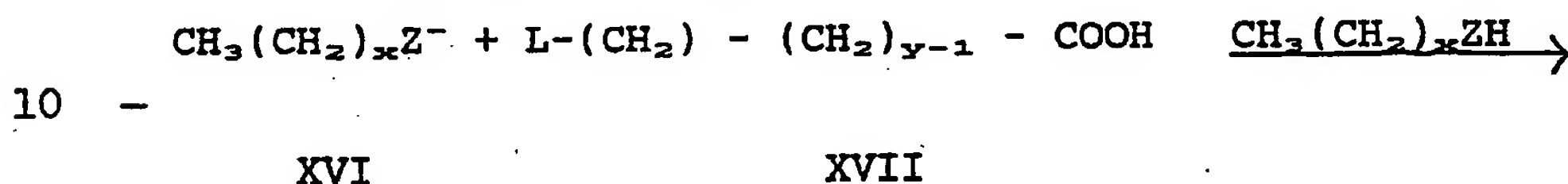
The general descriptions above are
specifically illustrated hereinbelow with representative
25 examples, AC-1, AC-2 and the lysoanalogs thereof. The
following application of the generalizations hereinabove
are provided solely for illustrative purposes. The
invention is not to be limited in any way by the
exemplification hereinbelow. The AC1 and AC2 and the
30 lyso compound are the most preferred embodiments of the
present invention and can be prepared by art recognized

- 1 synthetic procedures. Exemplary schemes are as outlined below.

Heteroatom-fatty acids

- 5 The general synthetic scheme for synthesizing hetero-atom-fatty-acids is outlined in EPA 0,415,902, which is incorporated herein by reference.

Synthetic scheme:



- 10 $\text{CH}_3(\text{CH}_2)_x\text{Z} - (\text{CH}_2)_y - \text{COOH}$
- 15 wherein x, y and Z are as defined hereinabove and L is a leaving group, such as halo, OTS, OMS and the like. A base having Formula XVI is reacted with a carboxylic acid of Formula XVII under Williamson-like conditions in $\text{CH}_3(\text{CH}_2)_x\text{ZH}$. The reaction is run at effective
- 20 temperatures, which may range from room temperature up to reflux temperatures, although it is preferred that the reaction be carried out under reflux temperatures. The following example illustrates the formation of the heteroatom fatty acids.

- 25 The general synthetic scheme for obtaining 12 MO is outlined below. A flame dried 300-ml round bottom flask was cooled before 8.4 g (0.030 mol) of 12-bromododecanoic acid was mixed with 6.5 g (0.120 mol) sodium methoxide in 200 ml of absolute methanol. The
- 30 yellow solution was refluxed at 85°C for 16-20 hours under a nitrogen atmosphere. After refluxing, the mixture was allowed to cool and the solvent was removed

1 by rotoevaporation. After removing most of the solvent,
approximately 2-4 milliliters of residue remained and
was extracted by the addition of ethyl acetate 100 ml,
ether 50 ml and H₂O 50 ml. Prior to acidification, the
5 organic layer was clear and the top aqueous layer was
yellow. This organic/aqueous mixture was acidified to
pH 3 with 1 N HCl causing the organic layer to yellow
and the aqueous layer to become clear. The aqueous and
organic layers were separated and the aqueous layer was
10 extracted twice with 30-50 ml of ethyl acetate. The
organic extracts were pooled and washed once with 50 ml
of H₂O. The organic layer was dried using anhydrous
Na₂SO₄ and filtered. After removing the solvent by
rotoevaporation, the residue was heated (50°C) under
15 vacuum for 5 hours to remove trace organic solvents.
TLC analysis using ethyl acetate:hexanes:formic acid
88:9:3, gave $R_f = 0.25$. Typical yields range from about
80-95%.

20 Hetero-atom-fatty-acid anhydrides

The corresponding anhydride of the heteroatom
fatty acid is formed by coupling the heteroatom fatty
acid with a dehydrating agent, such as
dicyclohexylcarbodiimide, as illustrated by the
25 exemplary procedure hereinbelow.

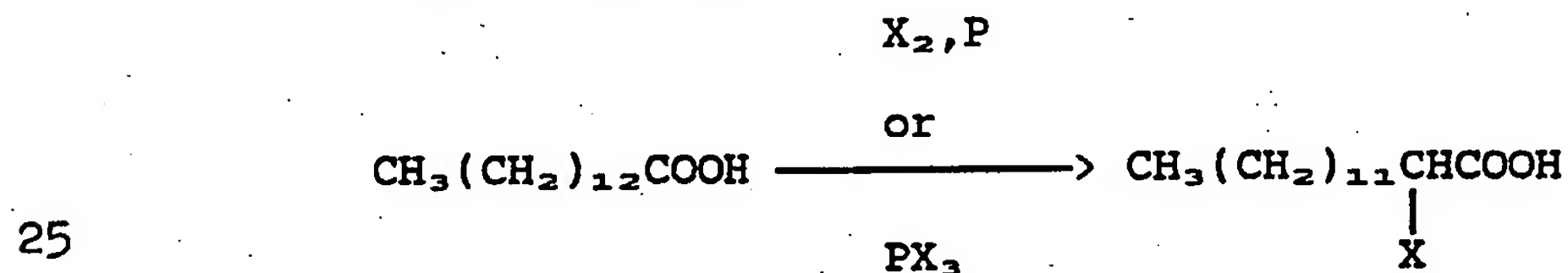
The anhydride was prepared in a flame dried
50-ml round bottom flask containing 5.4 g (0.024 mol) of
12-methoxydodecanoic acid completely dissolved in 20 ml
of dry THF under a nitrogen atmosphere. After adding
30 DCC 2.40 g (0.012 mol) dropwise over 5 minutes, the
reaction was complete in under 25 minutes as monitored
by the disappearance of the DCC imine vibration band

1 (centered at 2100 cm^{-1}). Preliminary studies showed if
 solid DCC was added to the reaction mixture then several
 side products were found by TLC. Consequently DCC was
 melted, weighed into a flame dried beaker, and diluted
 5 with 5 ml of dry THF. Dicyclohexylurea (DCU) precipi-
 tates within the first few minutes of DCC addition. DCU
 was removed by paper filtration (Whatman #1). The
 solvent was removed by rotoevaporation and placed under
 a heated vacuum (50°C) for 12 hours. FTIR and TLC
 10 analysis (ethyl acetate:hexanes:formic acid 88:9:3)
 revealed no DCU or DCC in the final product. Typical
 yields were 90-95%.

15 Substituted myristic acid analogs

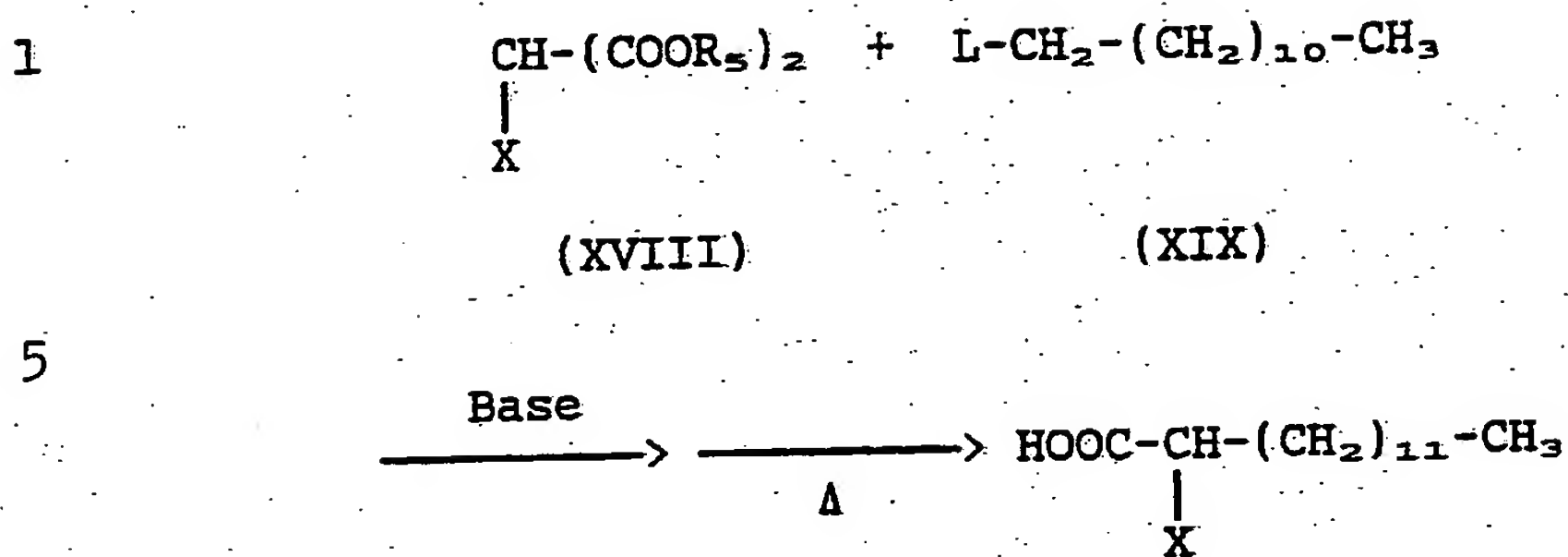
The synthesis of the substituted myristic acid
 is also prepared by art recognized techniques. Although
 the reaction substrate described hereinbelow is myristic
 acid, the following examples are exemplary and are
 20 applicable to fatty acids in general.

The fatty acid can be halogenated as follows:



wherein X is halo, e.g., bromo or chloro. The fatty
 acid is halogenated with phosphorus in the presence of
 halogen, or with PX_3 under Hell-Volhard-Zelinsky
 30 reaction conditions to form the α -halogenated product.
 Alternatively, the acid may be formed in two steps using
 a variation of the malonic ester synthesis:

35



10 In the above scheme, X is halo, R₅ is lower alkyl, such as methyl, ethyl and the like, and L is a better leaving group than X, such as OTS, OMS and the like. For example, if X is F, then L may be OTS, OMS, Br, I and the like.

15 As described hereinabove, the halo malonic acid ester (XVIII) is reacted with a strong base to remove the acidic hydrogen on the α-carbon. The resulting anion is then reacted with an alkyl halide (XIX) and forms the coupled diester. The reaction is run in an inert solvent, such as dimethyl formamide, and preferably under anhydrous conditions. The resulting product is then heated at temperatures effective for decarboxylation to form the final product.

The reaction is further exemplified by the following example.

25 The general synthetic scheme for synthesizing substituted myristic acid analogs is similar to the synthesis of 2-fluoromyristic acid which can be synthesized as follows: To a suspension of 0.32 g (11.2 mmol) of an 80% oil dispersion of NaH in 8 mL of dry DMF was added dropwise 2 g (11.2 mmol) of diethyl fluoromalonate under argon. The suspension was then stirred for 4.5 h after which time, 2.79 g (11.2 mmol)

1 of 1-bromododecane was added and the solution was heated
at 90°C for 18 h. The yellow suspension was then poured
into 10 mL of water and extracted with ether (2 x 15
mL). The combined ether layers were washed, dried and
5 evaporated. A yellow oil resulted, which was used for
the next reaction without further purification. A
mixture of 3.8 g of the crude
diethyldodecylfluoromalonate (8), 30 mL of 6 N HCl, and
50 mL of dioxane was refluxed for 72 h. After cooling,
10 the yellow solution was dissolved in 100 mL of petroleum
ether (bp 40-60°C). The organic layer was separated and
washed with water (3 x 50 mL) and 10% KOH (2 x 250 mL).
The combined aqueous layers were acidified to pH 1.0
with concentrated HCl and extracted with ether (3 x 100
15 mL). The ether layer was dried, filtered and evaporated
to dryness to yield a green solid. The solid was
decolorized with activated carbon and recrystallized
from petroleum ether (bp 40-60°C) to give 1.501 g (54%
overall yield) of 2-fluoromyristic acid (2) as white
20 needles.

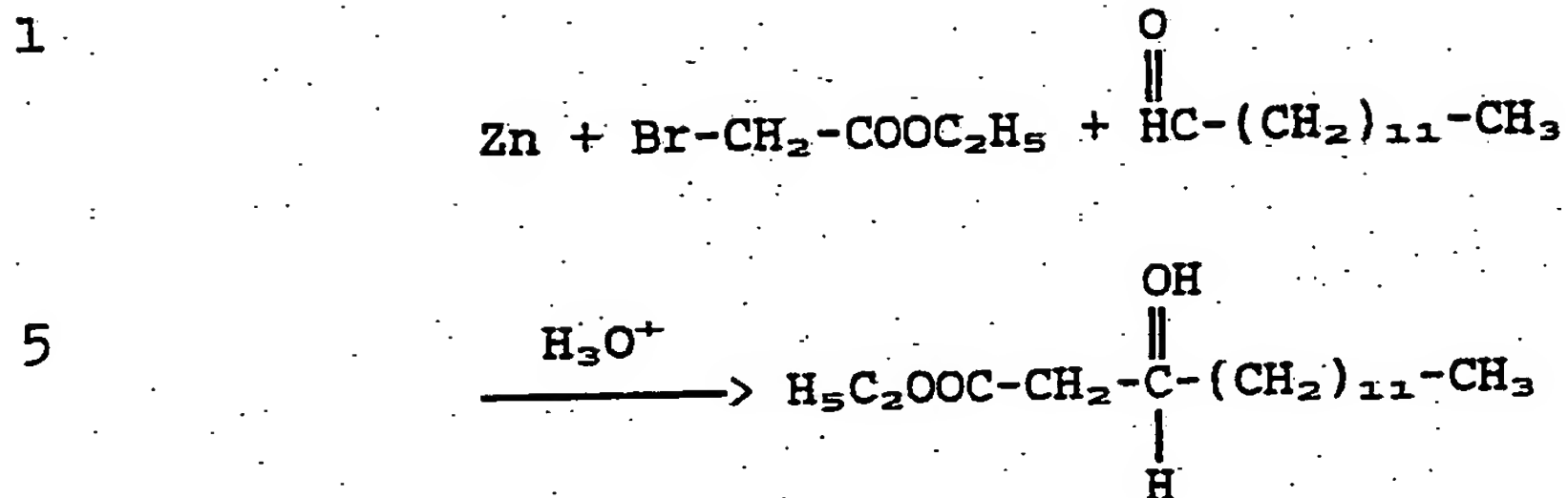
2-bromomyristic acid was purchased from
Aldrich and 2-hydroxymyristic acid was purchased from
Fluka.

A beta hydroxy acid can be formed by reacting
25 a β -halo ester with an aldehyde in the presence of zinc
under Reformatsky reaction conditions in an inert
solvent, such as toluene or DMF.

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The resulting product is then hydrolyzed to form the corresponding acid.

10 The β -hydroxy compound can then be converted to the corresponding halide by art recognized techniques, such as reaction with thionyl bromide or chloride, phosphorous trihalide, (SO_2Cl_2 , SO_2Br_2 , PCl_3 , PI_3) and the like.

15 The corresponding anhydrides of the substituted fatty acid analog can be prepared by coupling the substituted fatty acid analog prepared hereinabove with a dehydrating agent, such as decyclohexylcarbodiimide, as illustrated by the
20 exemplary procedures hereinabove.

Phospholipids

The phospholipids are prepared by art recognized techniques by reacting an acylating
25 derivative of the fatty acid, such as the fatty acid anhydride, with the glycerol phosphate of the formula:



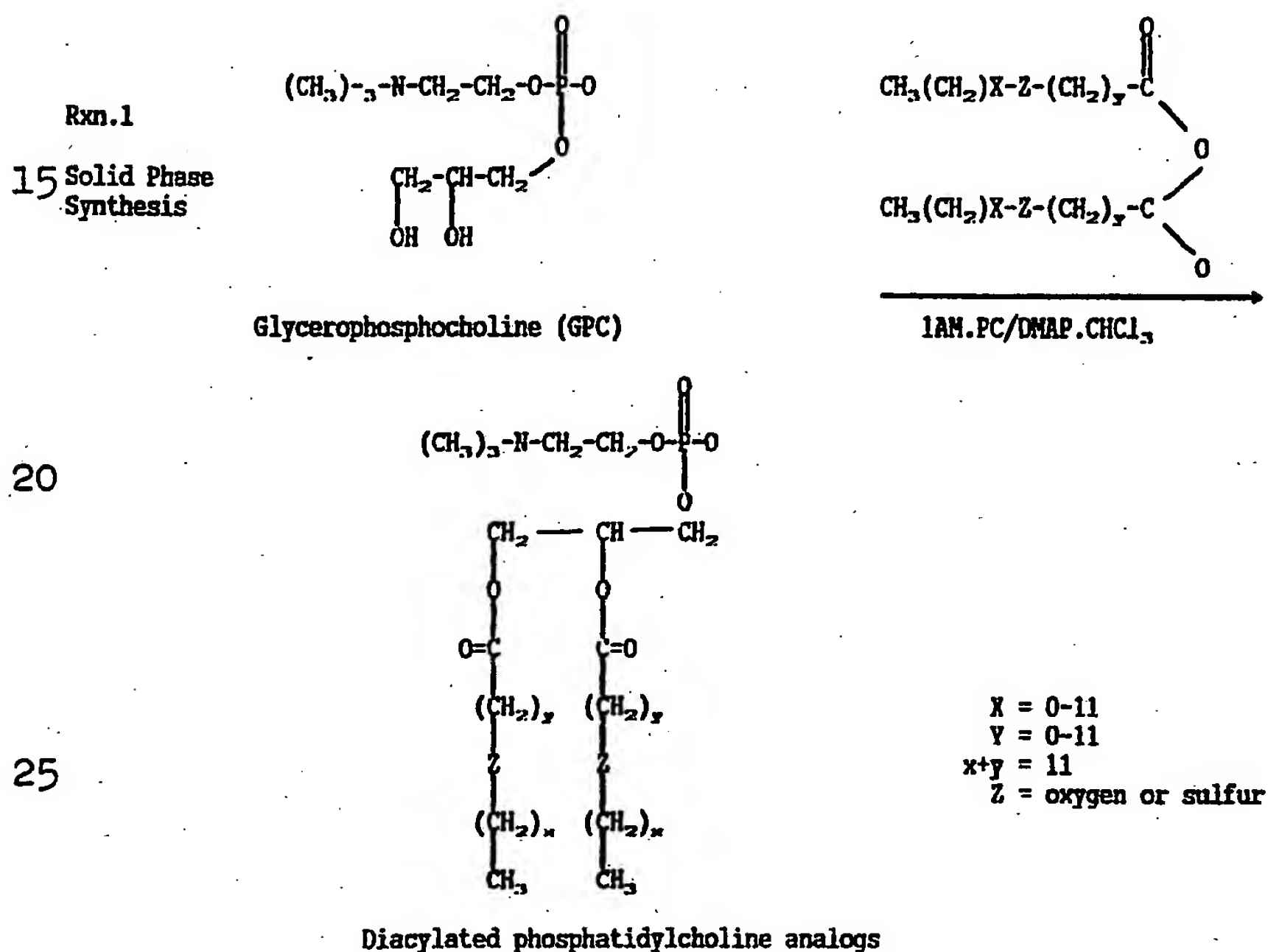
wherein R is as defined hereinabove, under esterification conditions. This reaction is illustrated

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1 hereinbelow. Although the reaction is illustrated using the heteroatom fatty acid to form the heteroatom fatty acid phospholipid, the reactions described hereinbelow are applicable using the substituted fatty acid analogs 5 to form the phospholipid containing the substituted fatty acid analogs.

The chemical reaction for the solid phase adsorption synthesis of L-AC2 is given in Rxn. 1. The synthetic route for obtaining the anhydride used in Rxn. 101 is given above.



1 Phospholipids are not difficult to synthesize,
but the present novel-synthetic-method overcomes several
experimental inconveniences associated with phospholipid
synthesis. During the synthesis of diacylated
5 phospholipids, an experimental inconvenience involves
the insolubility of glycerophosphocholine (GPC) in
common organic solvents. Although GPC is soluble in
dimethylsulfoxide (DMSO), the use of DMSO requires
vacuum distillation and in addition, DMSO makes the
10 purification of phospholipids more difficult. The
inventors have developed a novel method for synthesizing
molecules when all reactants are not soluble in the same
organic solvent. The method involves using a chro-
matographic surface to promote the interaction between
15 one insoluble reactant and one soluble reactant. In
other words, the insoluble-reactant is initially
adsorbed to the chromatographic surface, and the
soluble-reactant partitions into the chromatographic
interface during the reaction. Partitioning of the
20 soluble-reactant between the chromatographic surface and
the reaction solvent permits the insoluble molecule,
adsorbed at the interfacial region, to react with the
soluble reactant. Although other chromatographic
surfaces may be useful, IAM.PC chromatographic surfaces
25 were utilized.

The synthesis of AC2 demonstrates the solid-
phase-synthetic procedure shown in Rxn. 1. GPC (250 mg,
1 mMol) solubilized in MeOH (0.5 ml), was adsorbed to
IAM.PC (200 mg) by dropwise addition of the methanolic-
30 GPC solution; the MeOH was allowed to evaporate after
the IAM.PC surface was completely loaded with GPC. The
IAM.PC/GPC solid material was dried overnight in a

1 vacuum oven at 45°C. After drying, the IAM.PC/GPC
powder was then suspended in dry CHCl₃ containing 1
equivalent of the appropriate anhydride per GPC alcohol,
and 1 equivalent of catalyst (i.e.,
5 dimethylaminopyridine denoted as DMAP). Both the
anhydride and DMAP were dried by vacuum at 45°C. After
6 hours, TLC confirmed the reaction was complete, and
the phospholipid product was purified by acetone
precipitation and/or silica chromatography. Normally
10 the synthesis would have required 4-5 days per
phospholipid and 2 equivalents of anhydride, but this
method requires approximately 1-2 days and 1 equivalent
of anhydride.

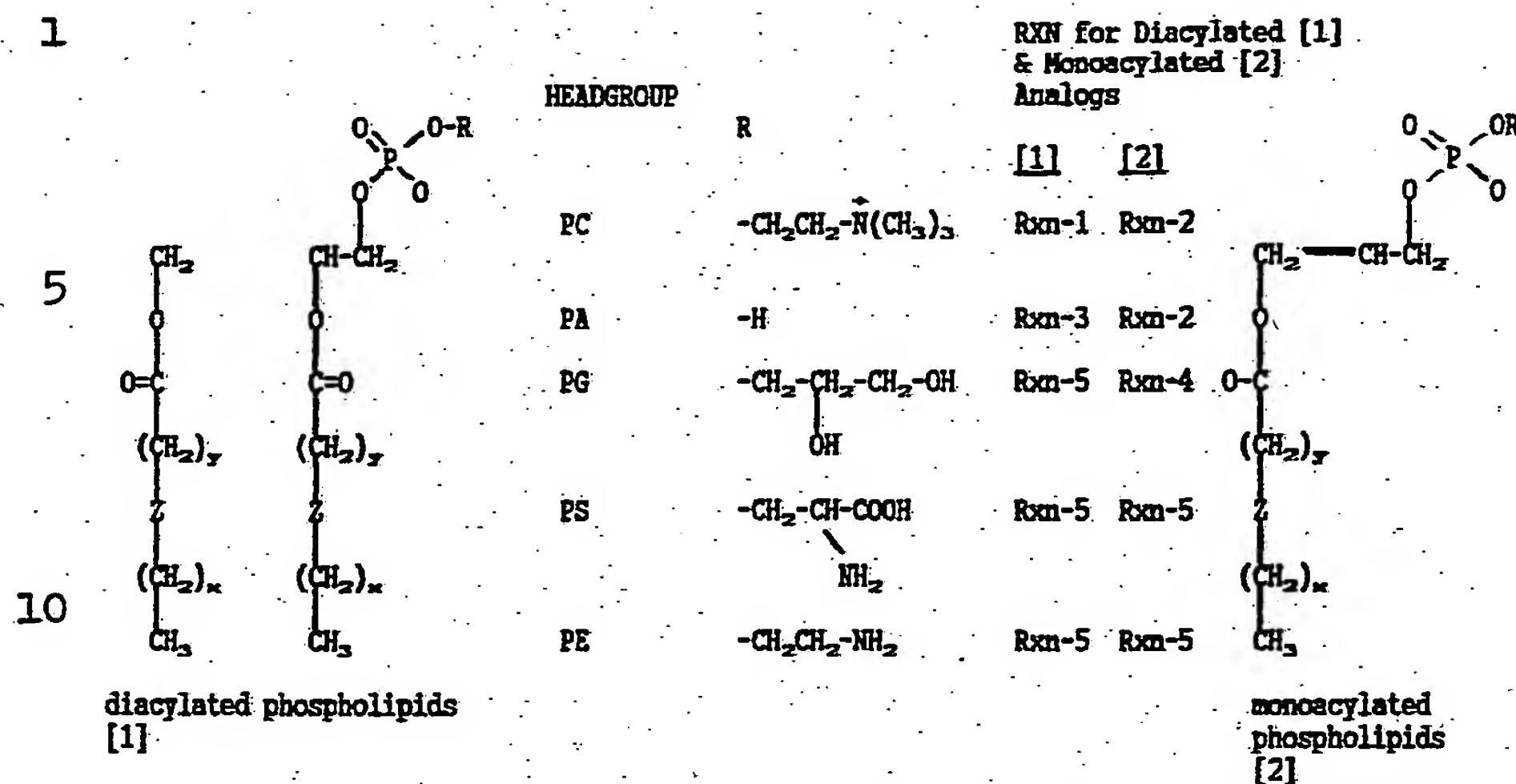
General structures of mono- and diacylated
15 phospholipids whereby all alkyl chains are biologically
active fatty acids are shown below. For both the mono-
and diacylated phospholipids: $x = 0-11$; $y = 0-11$, and x
 $+ y = 11$ for any given analog. "Z" denotes the hetero-
atom and will be either oxygen or sulfur. The chemical
20 reactions for the synthesis of each compound is also
given below.

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Chemical reactions 2-6 for the above synthetic routes are illustrated below. Briefly, diacylated analogs were prepared by a solid-phase adsorption method (see Rxn. 1 at Pages 54-55 of the application), monoacylated analogs can be prepared from phospholipase A2 treatment of the diacylated compounds, and diacylglycerol analog can be prepared from a separate reaction scheme (i.e., reaction 6). Reaction 6 involves first protecting glycidol epoxide using diphenylsilyl-(t)-butylchloride to form glycidol-tert-butyl diphenylsilyl ether. The epoxide ring is then opened with base, and the protected glycerol is diacylated with 12-methoxydodecanoyl anhydride. The final step in reaction 6 involves deprotecting the diacylglycerol sn-3 alcohol using n-butylammonium fluoride.

Diacylated phosphatidylcholine analogs containing oxygen or sulfur substituted for methylenes can be hydrolyzed with phospholipase A2 to obtain the corresponding lysolecithin analogs.

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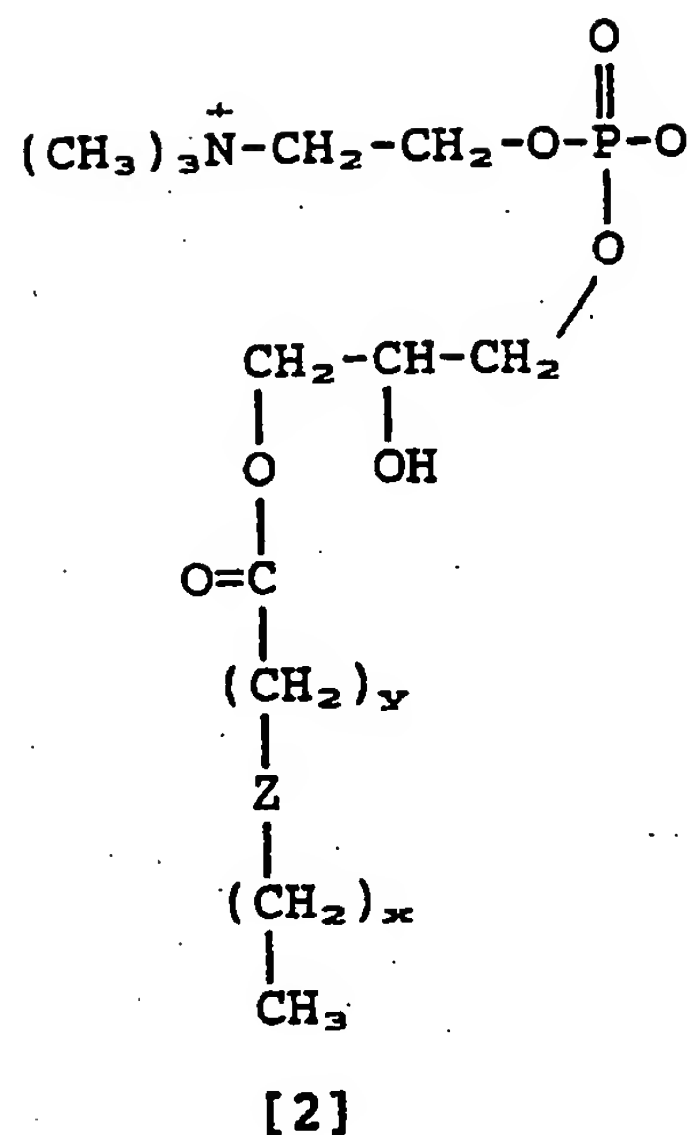
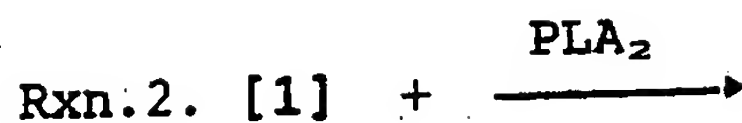
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Monoacylated Phosphatidylcholine

Diacylated phosphatidic acid analogs can be synthesized by reacting L-glycerol-3-phosphate with the appropriate anhydride on the surface of an immobilized artificial membrane particle. This reaction was described in detail in the discussion of reaction 1 using glycerophosphatidylcholine as starting material (see Reaction 3).

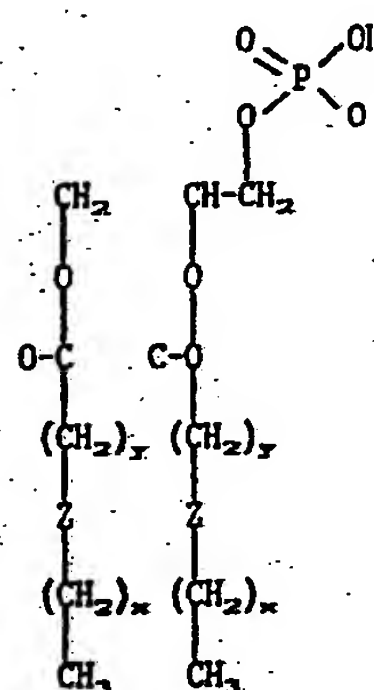
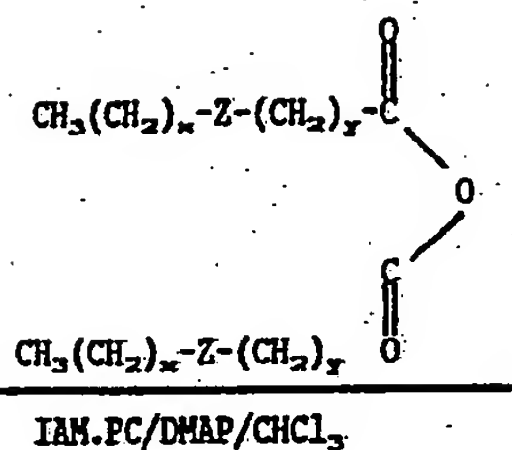
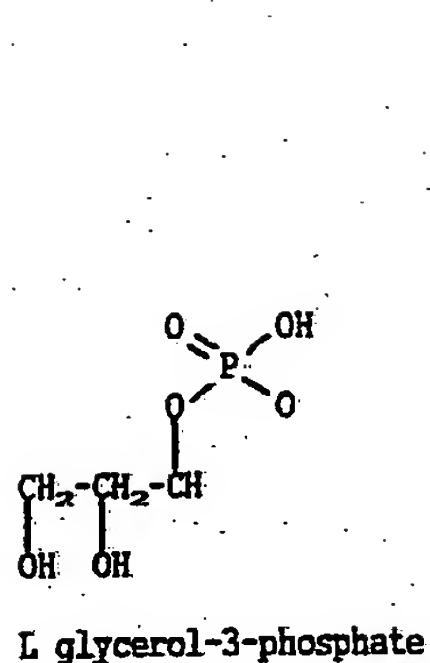
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Rxn.3.

Solid Phase

[3]



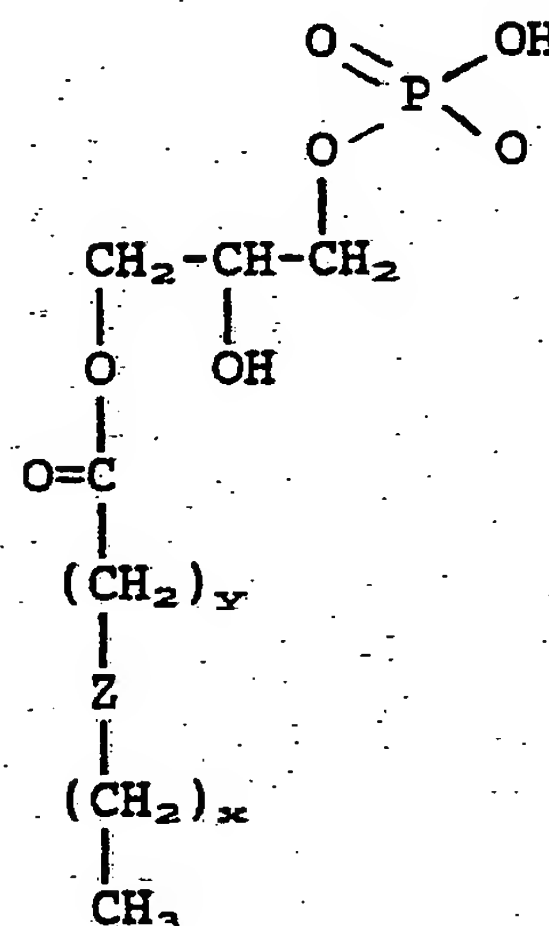
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Monoacylated analogs of phosphatidic acid can be obtained by phospholipase A₂ cleavage of the diacylated analogs denoted by [3] in reaction 3. This reaction is described hereinbelow:

15

20 Rxn.4

[3]

PLA₂

[4]

Monoacylated phosphatidic acid

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1 Diacylated analogs containing either a
glycerol (PG), serine (PS), or ethanolamine (PE)
headgroup can be synthesized by transphosphatidylation
using phospholipase D treatment of diacylated
5 phosphatidylcholine analogs denoted as [1] in rxn. 5.
The lysolipid analogs with these headgroups can then be
obtained by further reaction with phospholipase A2
cleavage.

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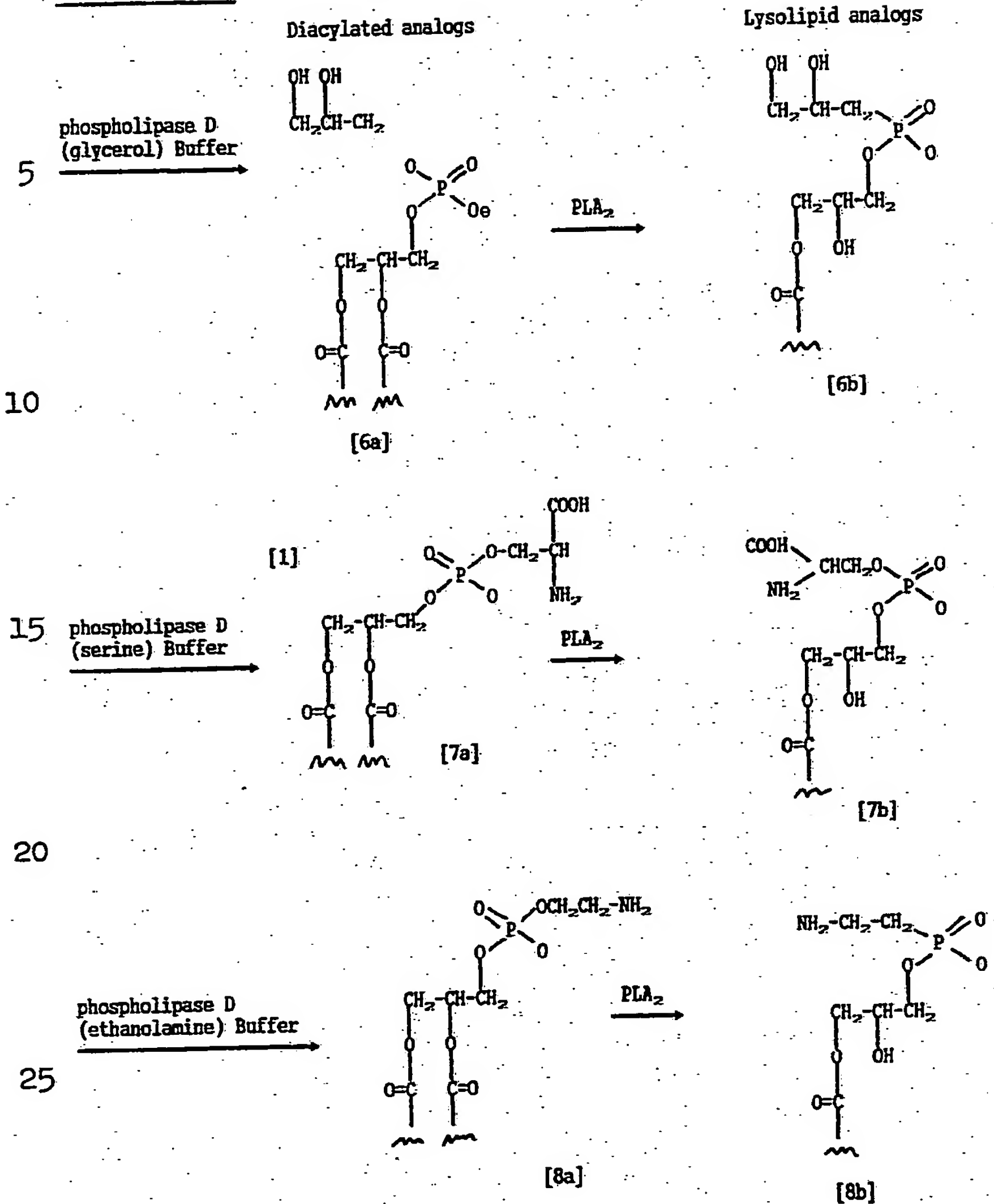
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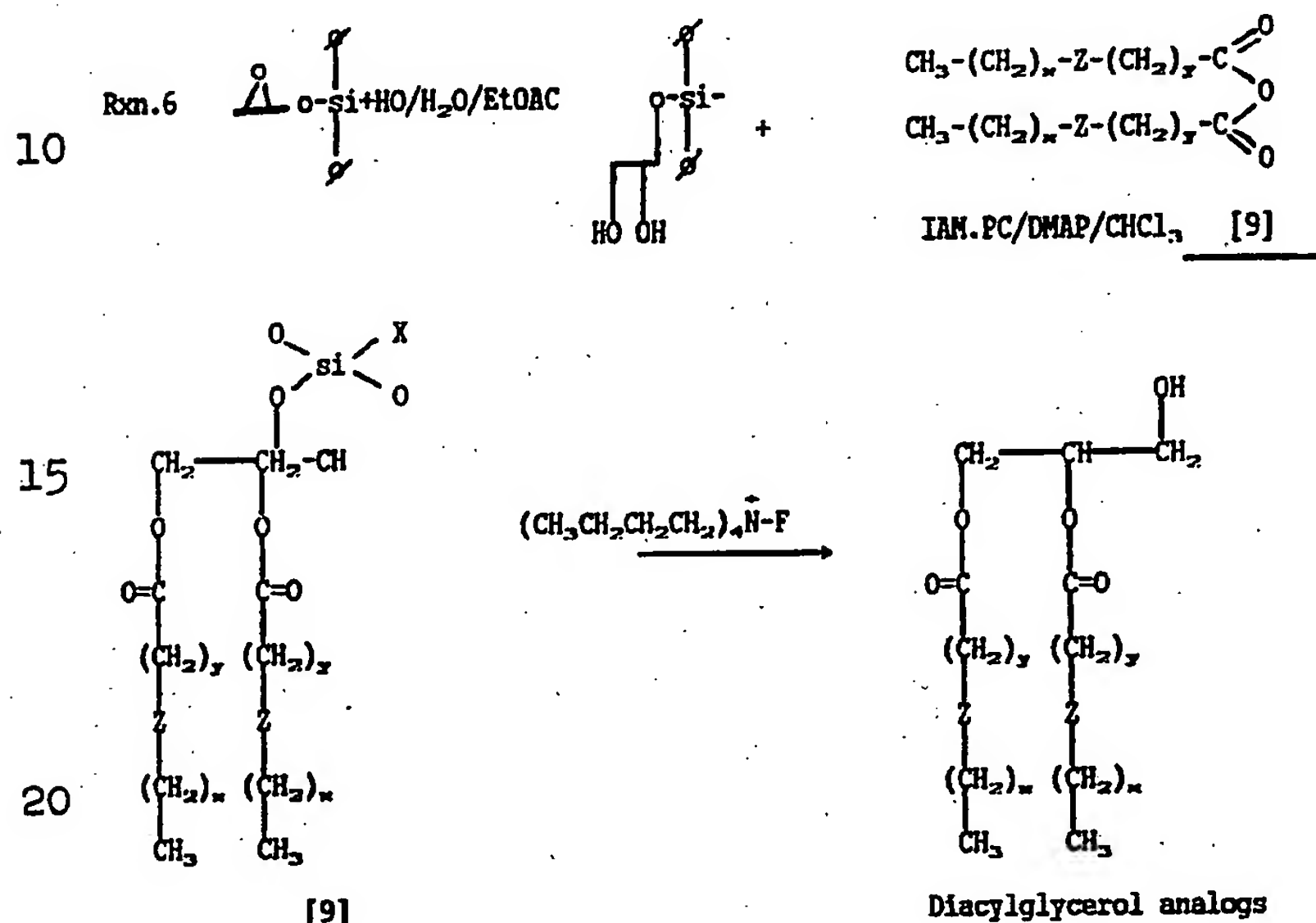
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1 REACTION 5



30 (m) denotes the rest of the fatty acid chain.

- 1 Diacylglycerol analogs containing two identical hetero-atom-fatty acids can be synthesized from (t)butyldi-phenylsilyl-O-glycidol. This reaction is performed by solid phase adsorption method employed in reaction 1 using glycerophosphatidylcholine as substrate, as shown below.



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EXAMPLES

GENERAL SYNTHESIS

Lecithins are 'diacylated' phospholipids and scheme 1 and scheme 2 shows the general synthetic pathway used to obtain anti-HIV lecithins containing the phosphatidyl-ethanolamine headgroup. Scheme 1 shows the general synthetic scheme used to prepare a lipid containing two 12-methoxy-dodecanoyl groups and a phosphatidylethanolamine headgroup; this lipid is denoted as di-12MOGPE. Briefly, L- α -GPE was reacted with Fmoc-NHS to form GPE-Fmoc in a mixed solvent system; this reaction protected the 1° amine of GPE. GPE-Fmoc was then acylated with 12-MO-anhydride in dry chloroform to form the diacylated product (di-12MOGPE-Fmoc). Di-12MOGPE was then obtained by removing Fmoc with piperidine. Scheme 2 shows the general synthetic scheme used to prepare the anti-HIV lecithin containing one 12-methoxydodecanoyl group and one saturated fatty acid. Briefly, monomyristoylphosphatidylethanolamine (MMPE) was reacted with Fmoc-NHS to form MMPE-Fmoc; this reaction protected the 1° amine of MMPE. MMPE-Fmoc was then acylated with 12-MO-anhydride in dry tetrahydrofuran to form the diacylated product 1-M-2-12MOGPE-Fmoc. 1-M-2-12 MOGPE was then obtained by removing the Fmoc group with piperidine.

Scheme 3 shows the general synthetic scheme used to prepare the anti-HIV lipid containing the phosphatidylcholine headgroup. Briefly, diacylated lecithins were prepared from both the L and D form of glycerophosphocholine (L- α -GPC and D- α -GPC) by acylation using 12-MO anhydride. The single chain analog of the L configuration was then prepared from phospholipase A2

35

1 cleavage of the diacylated product. For all reactions described above, acylation using the 12-MO-anhydride used 2 equivalents of anhydride per alcohol and 1.5 equivalents of catalysts (DMAP) per alcohol.

5

CHEMICAL AND SOLVENTS

Chemicals and solvents were used as received unless stated otherwise. 1-myristoyl-sn-glycero-3-phosphoethanolamine (MMPE) was purchased from Avanti Polar Lipis Inc. (Birmingham, AL). L- α -glycerophosphoethanolamine (GPE) and N-(9-Fluorenylmethoxycarbonyloxy) succinimide (Fmoc-NHS) were purchased from Sigma Chemical Company. D- α -glycerophosphocholine was purchased from Biochemisches Labor, Berne CH, Switzerland. Dimethylaminopyridine (DMAP) purchased from Aldrich was crystallized 2 times from ethyl ether. Dicyclohexylcarbodiimide (DCC) was purchased from Aldrich. Sodium bicarbonate (NaHCO_3) was obtained from Fisher Scientific Chemical Company. 20 Analytical grade chloroform (CHCl_3), methanol (MeOH), and tetrahydrofuran (THF) were obtained from Fischer Scientific. H_2O was double distilled from glass containers. Dry THF and Dry CHCl_3 were prepared by distillation over calcium hydride. Calcium hydride was 25 purchased from Alpha Products, Danver, MA. 12-methoxydodecanoic acid 12MO was prepared as described hereinabove. 12-methoxyldodecanoyl anhydride (MO-anhydride) was prepared using DCC and purified by crystallization using ethylacetate. Piperidine was 30 obtained from Fisher Scientific Chemical Company. Ninhydrin and Phospray were purchased from Supelco Inc. Bellefonte, PA.

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1 Thin layer chromatography (TLC) was used to
monitor all reactions. Silica gel TLC plates were 60 F-
254, 0.25 mm thickness (E. Merck, Darmstadt, FGR). Two
TLC solvent systems were used: solvent system A
5 contained $\text{CHCl}_3/\text{CH}_3\text{OH}/\text{H}_2\text{O}$ 65:25:5 V:V:V; solvent B
contained $\text{CHCl}_3/\text{CH}_3\text{OH}/\text{H}_2\text{O}/\text{THF}$ 64:34:7:30 V:V:V:V. TLC
plates were sprayed with either Ninhydrin (Supelco Inc.
Bellefonte, PA) to visualize amines or Phospray (Supelco
Inc. Bellefonte, PA) to visualize phosphate. The extent
10 of reaction was routinely quantified using a scanning
densitometer (Shimadzu CS 9000) operating in the
reflectance mode. TLC plates were sprayed with Phospray
prior to scanning at 600 nm. Phospholipid standards
were always included on the same TLC plate used for
15 lipid quantification. Silica gel for flash
chromatography was grade 60, 230-400 mesh and obtained
from Aldrich Chemical Company. The solvent systems
described hereinabove were also used to purify the
heteroatom containing phospholipid drugs by flash
20 chromatography.

L- α -glycerophosphoethanolamine-
Fluorenylmethyloxycarbonyl (GPE-Fmoc).

GPE (93 μmole , 20 mg), Fmoc-NHS (130 μmole , 45
25 mg) and NaHCO_3 (288 μmoles , 24 mg) were transferred into
a round bottom flask, and 10 mls of $\text{CHCl}_3/\text{CH}_3\text{OH}/\text{H}_2\text{O}$
(32:17:2 V:V:V) was immediately added to the flask. The
reaction mixture was stirred at room temperature. GPE
and Fmoc are soluble in this solvent system but NaHCO_3
30 is only slightly soluble. Based on TLC in solvent
system A, quantitative yields are obtained in
approximately three and half hours. The reaction

-59-

- 1 mixture was filtered to remove NaHCO_3 (solid) and the
filtrate was rotoevaporated to dryness. After
rotoevaporation the residue was redissolved in CHCl_3 (~1
ml) and loaded on to dry silica gel loosely packed in a
5 cylindrical glass frit filtration funnel (~5 g of silica
per 1 g of reaction mixture). The unreacted Fmoc-NHS
washed off with CHCl_3 (10 mls), and NHS washed off with
 CH_3OH (10 mls). The product was then washed with
 $\text{CHCl}_3/\text{CH}_3\text{OH}$ 1:1 V:V (10 mls) to obtain pure GPE-Fmoc.
10 GPE-Fmoc (R_f of 0.24) shows one spot on TLC plates
developed in solvent system A. GPE-Fmoc is UV positive,
Phospray positive, and Ninhydrin negative.

di-(12-methoxydodecanoyl)-sn-glycero-3-
15 phosphoethanolamine-Fluorenylmethyloxycarbonyl (di-
12MOGPE-Fmoc)

- GPE-Fmoc, MO-anhydride and DMAP were dried in
a vacuum desiccator at 40°C for at least four hours
before use. GPE-Fmoc (93 μmol , 40 mg), MO-anhydride
20 (410 μmol , 180 mg) and DMAP (200 μmol , 24 mg) were added
to a flame dried round bottom flask and freshly
distilled CHCl_3 (10 mls) was added. The reaction
mixture was under a N_2 atmosphere and stirred at 40°C .
After 20 hours, TLC in solvent system A confirmed that
25 the reaction was virtually complete; the major product
di-12MOGPE-Fmoc had an R_f of 0.46. Rotoevaporation of
the reaction solvent left a dry residue which was
redissolved in minimal CHCl_3 (~1 ml). The CHCl_3
solubilized residue was loaded on to silica gel packed
30 inside a cylindrical glass-frit filtration funnel (~5 g
silica/g of residue). The unreacted MO-anhydride washed
off the silica with CHCl_3 (~200 ml); TLC in solvent

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1 system A was used to monitor MO-anhydride in the
filtrate. We note that it is important to remove MO-
anhydride from the crude product-mixture to avoid
decreased retention times and coelution of the products
5 and reactants during column chromatography. After the
anhydride was removed, $\text{CHCl}_3/\text{CH}_3\text{OH}/\text{H}_2\text{O}$ (60:35:5 V:V:V)
(~50 mls) was used to wash off the reaction products.
Rotoevaporation of the filtrate left a crude product-
mixture. The product mixture was redissolved in a
10 minimum volume of mobile phase $\text{CHCl}_3/\text{CH}_3\text{OH}/\text{H}_2\text{O}$ (65:25:4
V:V:V) and purified using flash chromatography (3 cm x
21 cm column, ~2 mg of reaction mixture per 1 g of
silica gel). Fractions eluting from the column (10
ml/fraction) were analyzed by TLC in solvent system A.
15 Fractions containing di-12MOGPE-Fmoc were pooled and the
solvent removed by rotoevaporation. The pure product
(di-12MOGPE-Fmoc) showed one UV positive TLC spot that
was also Ninhydrin negative and Phospray positive. The
yield was ~70%.

20

1,2 di-(12-methoxydodecanoyl)-sn-glycero-3-
phosphoethanolamine (di-12MOGPE)

di-12 MOGPE-Fmoc was dissolved in dry CHCl_3
(20 mg/ml) at room temperature and piperidine was added
25 [1:80 di-12MOGPE-Fmoc:piperidine]. Fmoc is completely
removed in 2 hours but if twice the amount of piperidine
is used, then 100% conversion occurs within 45 minutes.
On TLC in solvent system A, di-12-MOGPE has an R_f of 0.3
and is both Ninhydrin and Phospray positive but UV
30 negative which indicates that the Fmoc group has been
removed. The reaction solvent was removed by
rotoevaporation and the crude residue dissolved in 1 ml

35

1 of solvent system A and purified by flash chromatography
(3 cm x 21 cm) using the same solvent system. Fractions
were collected (10 ml/fractions) and analyzed by TLC in
solvent system A. Fractions containing the product were
5 pooled and the solvent removed by rotoevaporation to
obtain pure di-12MOGPE. The final lecithin product (di-
12MOGPE) exhibited one spot on TLC in solvent system A
and was Ninhydrin positive, Phospray positive, and UV
negative.

10 FAB-MS: MH^+ 640.3. IR (CaF_2 , neat) ν_{as} CH_2
2917.4; ν CH_2 2850.4; ν C=O 1738.4; δ_{as} CH_2 1454.0; ν_{as}
 PO_2 1230.6; ν C-O-C 1077.8; ν_s PO_2 1027.9. 1H NMR (500
MHz, $CDCl_3$) results: δ 5.18 ppm (br s, 1H, CH), 4.35
ppm (m, 1H, CH_2OP), 4.11 ppm (m, 1H, CH_2OP), 4.05 ppm
15 (br s, 2H, CH_2OP), 3.90 ppm (br s, 2H, CH_2OCO), 3.33 ppm
(t, 4H, OCH_2), 3.30 ppm (s, 6H, OCH_3), 3.12 ppm (br s,
2H, NCH_2), 2.28 ppm (m, 4H CH_2COO), 1.55 ppm (m, 8H
 CH_2CH_2COO , $CH_2CH_2OCH_3$), 1.25 ppm (br s, 28H, $(CH_2)_7$).

20 1,3 di-(12-methoxydodecanoyl)-sn-glycero-2-
phosphoethanolamine-Fluorenylmethyl-oxycarbonyl (1,3 di-
12MOGPE-Fmoc)

Headgroup migration occurred during the
preparation of di-12MOGPE-Fmoc and the migration product
25 was 1,3 di-12 MOGPE-Fmoc. This migration product was
purified by flash chromatography as described above for
di-12MOGPE-Fmoc. 1,3 di-12MOGPE-Fmoc exhibited one spot
on TLC in solvent system A with an $R_f = 0.4$.

1H NMR (500 MHz, $CDCl_3/CD_3OD$) results: δ 7.68
30 ppm (d, 2H, aromatic), 7.55 ppm (d, 2H, aromatic), 7.30
ppm (t, 2H, aromatic), 7.22 ppm (t, 2H, aromatic), 4.33
ppm (br s, 1H, $CHOP$), 4.28 ppm (d, 2H, CH_2CHCC), 4.10

- 1 ppm (t, 1H, CHCC), 4.15 ppm (m, 1H CH₂OP), 3.90 ppm (m, 1H, CH₂OP), 3.82 ppm (br s, 2H, CH₂OP), 3.80 ppm (br s, 2H, CH₂OCO), 3.42 ppm (br s, 2H, NCH₂), 3.30 ppm (t, 4H, OCH₂), 3.23 ppm (s, 6H OCH₃), 2.15 ppm (t, 4H, CH₂COO),
5 1.50 ppm (m, 8H CH₂CH₂COO, CH₂CH₂OCH₃), 1.20 ppm (br s, 28H, (CH₂)₇).

1-myristoyl-sn-glycero-3-phosphoethanolamine-
Fluorenylmethyl-oxycarbonyl (MMPE-Fmoc)

- 10 MMPE (9.88 mmoles, 4.2 g) and insoluble NaHCO₃ (29 mmoles, 2.4 g) were mixed in 50 mls of CHCl₃/CH₃OH/H₂O 32:17:4 V:V:V for 2 minutes at room temperature prior to the addition of Fmoc-NHS (13.3 mmoles, 4.5 g). After 2-3 hours the reaction was
15 virtually complete based on TLC in solvent system A. Without NaHCO₃ the yield was always 50-60% regardless of reaction conditions. The reaction was filtered through a fine glass-frit funnel to remove NaHCO₃ (solid) and the filtrate was rotoevaporated to obtain a residue.
20 The dry residue (~9 g) was redissolved in minimum CHCl₃ (2-3 ml) and loaded on to dry silica loosely packed in a glass filtration funnel (~5 g of the silica gel per g of reaction mixture). Based on TLC in solvent system A, unreacted Fmoc-NHS washed off the silica with CHCl₃
25 (~100 mls/g-product). After removing Fmoc-NHS from the product-mixture, both the phospholipid-product and NHS byproduct coeluted using ~300 mls of CHCl₃/CH₃OH/H₂O (32:17:4 V:V:V). The mixed solvent containing the product was removed by rotoevaporation and the residue
30 extracted with CHCl₃/CH₃OH/H₂O 8:4:3 V:V:V to remove NHS and other impurities. The product remained in the organic phase during the extraction. During extraction

1 approximately 20% of the product was lost into the
aqueous phase but was recovered by reextraction of the
aqueous phase with fresh organic solvent. MMPE-Fmoc was
an amorphous white solid after lyophilization from
5 benzene. The pure MMPE-Fmoc shows one spot (Rf of 0.36)
during TLC in solvent system A. MMPE-Fmoc is UV
positive, Phospray positive and Ninhydrin negative.
Product yields are 70-90% based on 2 reactions.

IR (CaF₂, neat) results: OH 3336.0 (broad);
10 ν_{as} CH₃ 3064.7; ν_{s} CH₃ 2953.1, ν_{as} CH₂ 2923.9; ν_{s} CH₂
2852.9; ν C=O 1721.7; ν 1533.8; δ_{as} CH₂ 1450.3; ν_{as} PO₂
1236.2; ν C-O-C 1108.5; ν_{s} PO₂ 1069.0. ¹H NMR (500 MHz,
CDCl₃/CD₃OD) results: 8.75 ppm (d, 2H, aromatic), 7.40
ppm (d, 2H, aromatic), 7.18 ppm (t, 2H, aromatic), 7.10
15 ppm (t, 2H, aromatic), 4.15 ppm (m, 1H, CH₂OP), 3.95 ppm
(t, 1H, CHCC), 3.90 ppm (d, 2H, CH₂CHCC), 3.75 ppm (m,
1H, CH₂OP), 2.70 ppm (br s, 2H, CH₂OP), 3.65 ppm (br s,
2H, CH₂OCO), 3.18 ppm (t, 2H, NCH₂), 2.08 ppm (t, 2H,
CH₂COO), 1.35 ppm (m, 2H CH₂CH₂COO), 1.05 ppm (br s,
20 20H, (CH₂)₁₀), 0.70 ppm (t, 3H, CH₃).

1-myristoyl-2-[12-methoxydodecanoyl]-sn-glycero-3-
phosphoethanol-amine-Fluorenylmethyloxycarbonyl (1-M-2-
12 MOGPE-Fmoc).

25 MMPE-Fmoc, MO-anhydride and DMAP were dried in
a 45°C vacuum desiccator for at least 4 hours. MMPE-
Fmoc (154 μ mol, 100 mg) was dissolved in freshly
distilled THF in a flame dried round bottom flask, and
12-MO-anhydride (632 μ mole, 280 mg) and DMAP (460 μ mol,
30 56 mg) were also dissolved in distilled THF but in a
separate flask. Both flasks were heated to 45°C and
after the reactants dissolved, MO-anhydride and DMAP

were carefully transferred to the flask containing MMPE-Fmoc (20 mg reactant/ml solvent). The reaction mixture was purged with nitrogen and stirred. After 1 hour the reaction was cooled to room temperature and allowed to react for another 14 hours. The solvent was removed by rotoevaporation and a minimum volume of CHCl_3 (~1-2 ml) was used to dissolve the residue. Unreacted MO-anhydride was removed from the reaction mixture and the product was purified as described above for di-12MOGPE-10Fmoc with the minor modification that the mobile phase solvent was solvent system B. The purified product (1-M-2-12MOGPE-Fmoc) exhibited one spot ($R_f = 0.48$) on TLC plates developed in solvent system B. 1-M-2-12MOGPE-Fmoc was Ninhydrin negative, phospray positive and UV positive. The yield was ~92% based on 1 reaction.

1-myristoyl-2-[12-methoxydodecanoyl]-sn-glycero-3-phosphoethanolamine (1-M-2-12MOGPE)

FMOC was removed from 1-M-2-12MOGPE-Fmoc by 20piperidine and the lecithin product (1-M-2-12MOGPE) purified by flash chromatography as described above for di-12MOGPE. Similar to purification of di-12MOGPE, the purification of 1-M-2-12MOGPE was simple because Fmoc elutes at the solvent front whereas piperidine remains 25at the origin when $\text{CHCl}_3/\text{CH}_3\text{OH}/\text{H}_2\text{O}/\text{THF}$ (64:34:7:30) is used as an isocratic solvent system during flash chromatography. The final product, 1-M-2-12 MOGPE, shows one spot on the TLC plates developed in solvent system A. 1-M-2-12-MOGPE is UV negative, and positive 30when sprayed with either Ninhydrin or Phospray. The yield was ~84 % based on 1 reaction.

1 FAB-MS: MH^+ 638.5. IR (CaF₂, neat) results:
v_{as} CH₂ 2918.3; v_s CH₂ 2850.6; v C=O 1739.0; δ_{as} CH₂
1467.4; v_{as} PO₂ 1230.8; v C-O-C 1078.8; v_s PO₂ 1028.2. ¹H
NMR (500 MHz, CDCl₃), δ 5.18 ppm (br s, 1H, CH), 4.35
5 ppm (m, 1H, CH₂OP), 4.11 ppm (m, 1H, CH₂OP), 4.05 ppm (b
s, 2H, CH₂OP), 3.90 ppm (br s, CH₂OCO), 3.33 ppm (t, 2H,
OCH₂), 3.30 ppm (s, 3 H, OCH₃), 3.12 ppm (br s, 2H,
NCH₂), 2.28 ppm (m, 4H, CH₂COO), 1.55 ppm (m, 6H
CH₂CH₂COO, CH₂CH₂OCH₃), 1.25 ppm (br s, 34 H, (CH₂)₇,
10 (CH₂)₁₀), 0.85 ppm (t, 3H, CH₃).

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1 Preparation of DAC2, LPE1 and LPE2

The preparation of D-AC2 was identical to L-AC2 except D-glycerolphosphocholine, which was obtained from Synthetische Phosphor-Lipide, Biochemisches Labor, 5 Bern CH Switzerland was used. L-PE2 was prepared by reacting glycerolphosphatidylethanolamine (L-a-GPE) with N-(9-Fluorenylmethoxycarbonyloxy) succinimide (FMOC-succinimide) to form L-a-GPE-FMOC followed by diacylation with 12MO anhydride then deprotection of 10 FMOC with piperidine. L-PE1 was prepared by diacylating L-a-GPE-FMOC with myristic anhydride, then PLA2 cleavage to remove the sn-2 chain, then acylation with 12MO anhydride, and finally deprotection with piperidine to remove FMOC.

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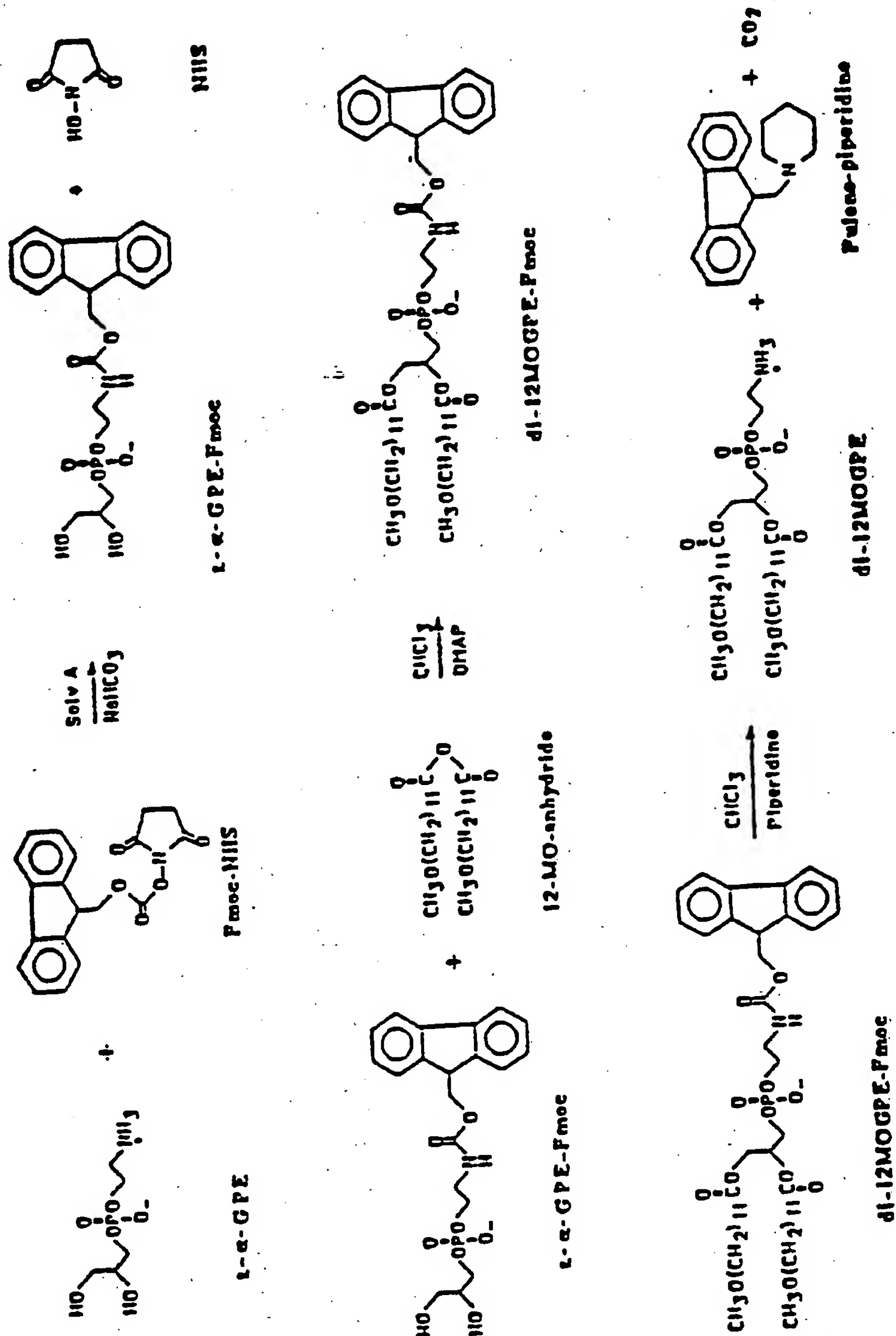
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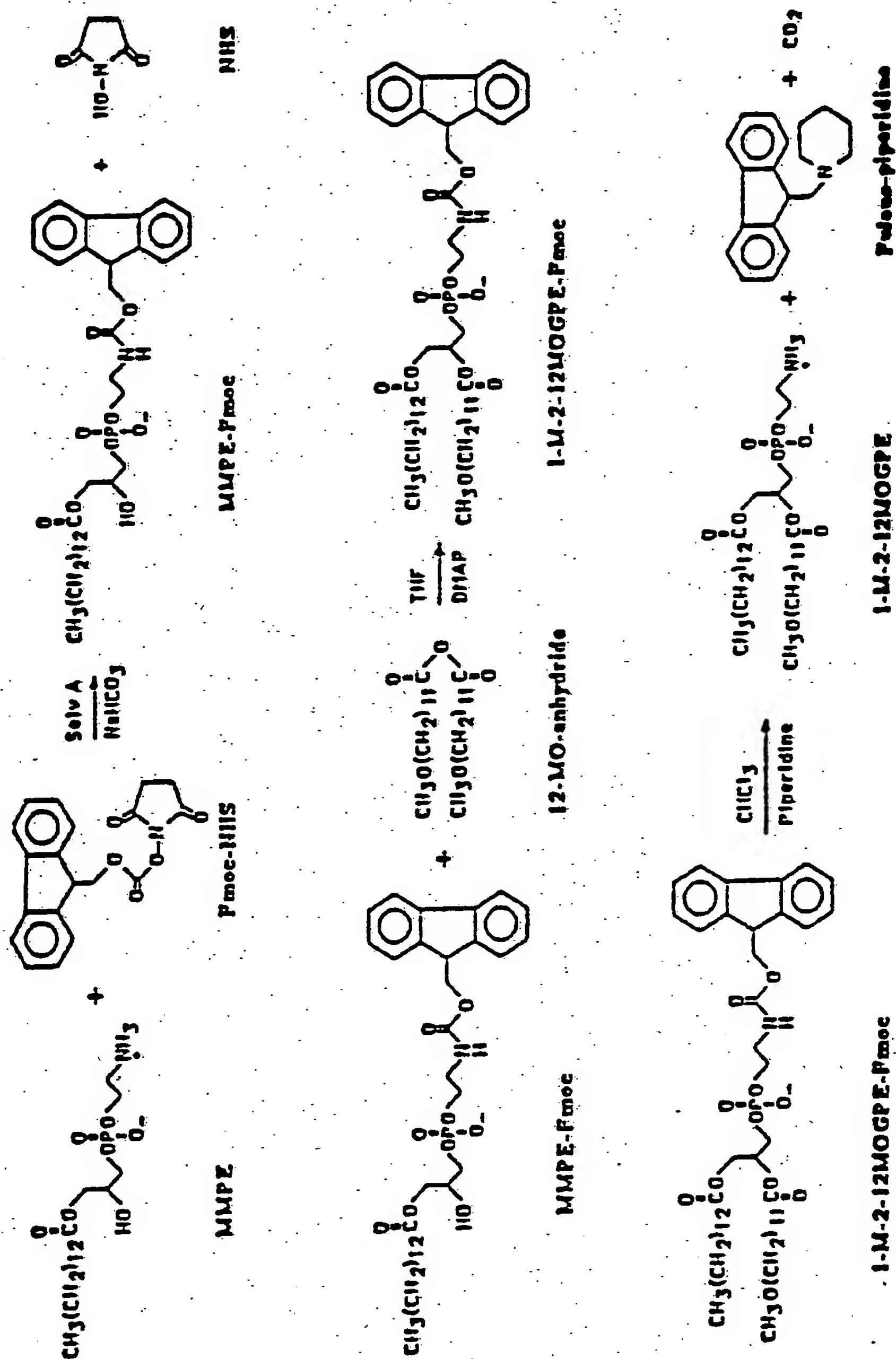
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Scheme 1

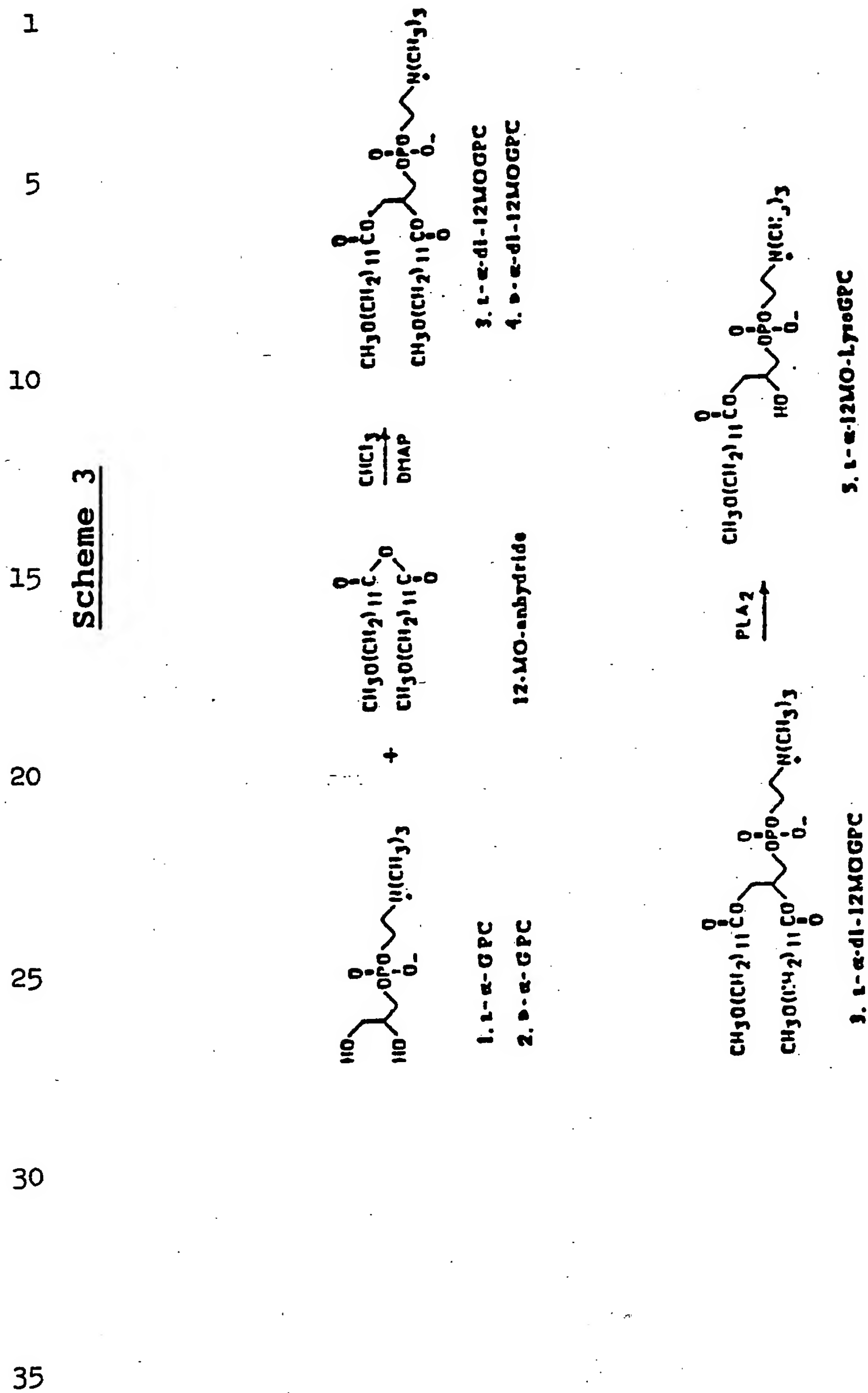


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Scheme 2



Scheme 3



1 Single chain phospholipid analogs are known to
form micelles, whereas double chain analogs form
liposomes. After injection into animals or man,
liposomes concentrate in macrophages, yet micelles do
5 not. Thus, phospholipid analogs containing biologically
active fatty acid molecules in the alkyl chains can be
modified such that the dispersion properties of the
phospholipids can be used to control, in part, the in
vivo disposition of these anti-HIV drugs. Macrophages
10 and T-cells are both CD4 positive cells and
consequently, HIV avidly infects both of these cells.
Thus, liposome forming anti-HIV drugs have unique
application for combination therapy against HIV,
particularly during viremia. If inhibitors of the HIV-
15 CD4 binding interaction are found and employed for HIV
therapy, then during viremia, HIV may not concentrate in
T-Cells. However, this may cause the HIV infection to
shift to other cells such as blood monocytes and
macrophages, which internalize foreign particles
20 regardless of the presence of CD4. The ability to
control the in vivo disposition of, for e.g.,
phosphatidylcholine anti-HIV compounds, by changing the
number of acyl chains on the phospholipids, is therefore
significant.

25 It is believed that liposome forming anti-HIV
active phospholipids will most likely not be able to
treat HIV infected tissue macrophages because liposomes
cannot efficiently exit the blood compartment of the
host. However, single chain lysolipid analogs which
30 form micelles are expected to distribute into tissues
outside of the blood compartment since lysolipid analogs

1 bind to albumin and are transported by albumin to
different tissues.

The incorporation of biologically active fatty
acids themselves into liposomes, for delivery to
5 mononuclear phagocytic cells, will also concentrate the
drug in blood monocytes/macrophages. However, no
control over the incorporation of hetero-atom fatty
acids into the cellular lipid pool exists for this
delivery system. In contrast, feeding cells
10 biologically active fatty acids covalently linked to
particular phospholipids allows some control over the
cellular disposition of the biologically active fatty
acids. Thus a key concept for the delivery of
biologically active fatty acids in the form of
15 phospholipids is that the in vivo disposition of the
drugs can be controlled by liposome forming analogs and
the cellular disposition of biologically active fatty
acids can be altered for therapeutic benefit by using
specific phospholipid headgroups for the preparation of
20 the drugs.

I. Experimental Designs and Methods

Overview of assay methods

Three assays for anti-HIV activity were used
25 and the IC_{50} was calculated from these assays; (i)
syncytial cell assays, (ii) reverse transcriptase
assays, and (iii) direct cytotoxicity assays. In
addition, direct drug cytotoxicity was tested 'as a
control' in each assay which merely means that the drug
30 was dosed to the cells without virus present. This
control assured that only the antiviral effect of the
compound is measured. However, this drug cytotoxicity

1 was not used to calculate the TC_{50} because the TC_{50}
required doses of drug that were higher than the
effective concentrations. Thus the TC_{50} is the dose of
drug that kills 50% of the cells without virus present
5 and was measured in MTT assays using the same cells type
to evaluate antiviral activity. The therapeutic index
was calculated from TC_{50}/IC_{50} . The ability of anti-HIV
phospholipids to inhibit direct cytopathic effect caused
by HIV infection was also measured.

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Anti-HIV activity of AC2, AC1, lysoAC2 and 12MO

Viral stocks

The S5G7 strain of HIV was used. S5G7 is a
subclone of HTLVIIIIB grown in H9 cells, and highly
15 virulent regarding T cell infectivity, but less so for
monocytes; this strain was obtained from Abbott
Laboratories.

Anti-HIV activity: (1) direct cytotoxicity assay

20 This assay measures the ability of a drug to
inhibit the HIV virus from killing cells. CEM cells
were used for this assay. The protocol is given in the
next two paragraphs.

The T-cell HIV inhibition assay method of
25 acutely infected cells is an automated tetrazolium based
colorimetric assay adapted from Novak, et al., Aids Res.
and Human Retroviruses, 6, 973 (1990). Assays were
performed in 96-well tissue culture plates. CEM cells
were grown in RPMI-1640 medium (Gibco) supplemented with
30 10% fetal calf serum and were then treated with
polybrene (2 μ g/ml). A 80 μ l volume of medium
containing 1×10^4 cells was dispensed into each well of

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1 the tissue culture plate. To each well was added a 100
2 μ l volume of test compound dissolved in tissue culture
3 medium (or medium without test compound as a control) to
4 achieve the desired final concentration and the cells
5 were incubated at 37°C for 1 hour. A frozen culture of
6 HIV-1 was diluted in culture medium to a concentration
7 of 5×10^6 TCID₅₀ per ml (TCID₅₀ = the dose of virus
8 that infects 50% of cells in tissue culture), and a 20
9 μ l volume of the virus sample (containing 1000 TCID₅₀ of
10 virus) was added to wells containing test compound and
11 to wells containing only medium (infected control
12 cells). This results in a multiplicity of infection of
13 0.1 (MOI = # of infectious virus particles/# of cells in
14 culture). Several wells received culture medium without
15 virus (uninfected control cells). Azidothymidine (AZT)
16 was tested as a positive drug control. Test compounds
17 were dissolved in DMSO and diluted into tissue culture
18 medium so that the final DMSO concentration did not
19 exceed 1.5%. DMSO had no significant effect on results
20 as determined in controls.

Following the addition of virus, cells were
incubated at 37°C in a humidified, 5% CO₂ atmosphere for
7 days. Additional aliquots of test compounds were
added on days 2 and 5. On day 7 post-infection, the
25 cells in each well were resuspended and a 100 μ l sample
of each cell suspension was removed for assay. A 20 μ l
volume of a 5 mg/ml solution of 3-(4,5-dimethylthiazol-
2-yl)-2,5-diphenyltetrazolium bromide (MTT) was added to
each 100 μ l cell suspension, and the cells were
30 incubated for 4 hours at 37°C in 5% CO₂ environment.
During this incubation, MTT is metabolically reduced by
living cells resulting in the production in the cell of

1 colored formazan product. To each sample was added 10
ml of 10% sodium dodecylsulfate in 0.01N HCl to lyse the
cells, and samples were incubated overnight. The
absorbance of each sample was determined at 590 nm using
5 a Molecular Devices microplate reader. The % reduction
of the virus induced cytopathic effect (CPE) by the test
compounds was calculated from the equation.

10
$$\% \text{ reduction CPE} = \frac{(\text{Abs compound-treated infected sample}) - (\text{Abs of virus control})}{(\text{Abs of cell control}) - (\text{Abs of virus control})} \times 100$$

The direct cytotoxicity of each compound to
CEM cells is labeled above each histogram bar in Figure
1. Starting from the top graph in Figure 1, AC1 was not
15 toxic to the CEM cells at dose up to 400 μM , AC2 was
toxic to CEM cells at 400 μM , lysoAC2 was not toxic up
to 400 μM , and 12MO was toxic to CEM cells at 400 μM but
12MO also showed toxicity at 40 μM . 12MO was the most
toxic analog tested in this series.

20 The IC_{50} of AC2 could not be accurately
determined from the data because the activity was too
high but the IC_{50} is less than 4 μMolar , and it is
estimated that the IC_{50} is $\sim 1 \mu\text{M}$. It is also
interesting that anchoring the biologically active fatty
25 acid in the sn-2 position significantly reduced the
activity (i.e., AC1 top graph), but the lysolecithin
analog containing the biologically active fatty acid in
the glycerol sn-1 position was active with an $\text{IC}_{50} \sim 100$
 μMolar . This may be due to the metabolism of lysolipids
30 compared to diacylated lipids or it may indicate the
myristoyl group is stored in the sn-1 chain of
endogenous membrane lipids. AC1 and the lyso compound

- 1 were significantly less toxic than the biologically
active fatty acid of AC2.

Anti-HIV activity: (2) macrophages

- 5 Anti-HIV activity was next measured in
macrophages using a p24 antigen capture assay. The
assay protocol is outlined below.

- Absorbance values (492 nm) for HIV-1 p24
antigen were detected by enzyme-immunoassay (EIA) in
10 culture supernatants of HIV-1 (3B) infected monocyte-
derived macrophages (MDM). Human peripheral blood MDM
were prepared by adherence to plastic in 24-well tissue
culture plates (Costar, Cambridge, MA). Briefly, 1×10^7
Ficoll-Paque (Pharmacia, Piscataway, NJ) gradient
15 purified mononuclear cells in RPMI-1640 with 20% heat-
inactivated fetal bovine serum, L-glutamine, and
gentamycin (Gibco, Grand Island, NY) were placed in each
well and allowed to adhere at 37°C for 3 hours. Non-
adherent cells were removed by gentle washing with warm
20 (37°C) Hank's balanced saline solution (HBSS-Gibco) and
the cells incubated in a 5% CO₂ in air atmosphere at
37°C in 2 ml of media. Remaining non-adherent cells
were further removed by washing again after 24 hours and
5 days. After 7 days in culture, the cells were
25 infected with HIV-1 3B by removing the media from each
well, washing with HBSS and adding 0.2 ml of virus-
containing supernatant from a 5 day culture of a MDM
permissive subclone of HIV-1 3B grown in H9 cells. The
plate was rocked at 37°C for 3.5 hr, the viral inoculum
30 removed and the cells washed 3 times each with 2 ml of
warm HBSS to remove non-MDM-associated viral particles.
Media containing 0, 1, 10, 50 or 100 µM of AC1, AC2 or

-76-

1 12MO were added to the appropriate wells and the cells
incubated as previously described. On days 1, 3, 6, 8,
10 and 15 after infection, 200 μ l of supernatants were
removed from each well for p24 antigen EIA assay (HIVAG-
5 1; Abbott Laboratories, North Chicago, IL). On day 8,
following the sampling for p24 antigen, 1 ml of fresh
media containing AC1, AC2, or MO was added to the
appropriate wells to restore a concentration of 1, 10,
50 or 100 μ M of each compound. Data is presented as
10 absorbance values reflecting HIV-1 p24 antigen
concentration produced by infected MDM as detected in
culture supernatants. The experiment shown in Figure 2
is representative of 3 experiments using 3 cell donors.
In Figure 2 the dose of drug is given above each bar in
15 the histogram, and -C is the negative control (no virus,
no drug).

Figure 2 shows that AC2 was very potent and
completely inhibited the AIDS infection in macrophages
at all doses tested. Even at the low dose of AC2, i.e.,
20 1 μ M, AC2 was completely effective. AC1 gave a dose
response with almost complete inhibition at 100 μ M.
12MO exhibited little activity except at 100 μ M where
the HIV infection was completely suppressed. At this
concentration, however, 12MO was toxic.

25

Anti-HIV activity: (3) Syncytial cell assays

Briefly, the assay was performed as follows.
On Day 0, MT4 cells were infected with HIV. On Day 3,
30 mix 10^3 - 10^4 infected cells (resuspend cells at 10^4 - 10^5
cells/ml so that the desired number of cells is in a
volume of 100 μ l) with 10^5 Supt1 cells (suspended at

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1 10^6 /ml, so that there are 10^5 cells per 100 μ l) in a 96
well plate. Infected cells are titered to find the
optimum number of syncytial cells to count. Cells are
counted either manually or by flow cytometry. Syncytia
5 begin to form at 8-10 hours, but optimum time for MT4
cells is about 18 hours. The time intervals for other
cell lines may vary. To assay drugs that block syncytia
formation, 50 μ l Supt1, 50 μ l infected (MT4) cells
(total cell number is the same), and 100 μ l of drug are
10 present. Typical results are shown in Figure 3 which
compares the IC_{50} of AC2 to 12MO. The IC_{50} of AC2 is ~ 1
 μ M and the IC_{50} of 12MO is ~ 4 μ M.

15 Antiviral Activity in PHA-Lymphoblasts: (4) Reverse
Transcriptase Assay

Mononuclear cells were obtained from the whole
blood of normal donors by ficoll/Hypaque (Pharmacia)
density gradient centrifugation. These cells are
initially washed with buffer and then stimulated with
20 PHA-M (Gibco) for 72 hours. The cells are then counted
for number, and also viability using trypan blue
exclusion, followed by infection with S5G7, a subclone
of HTLVIIIIB or a wild type strain, at a multiplicity of
infection (MOI) of 0.2 (i.e., 1 virus/5 cells) in a
25 volume of 0.2 ml of culture supernatants for 2 hours at
37°C. Control cells not challenged with virus are used
to evaluate drug toxicity. Cells are then washed three
times in RPMI + 10% fetal calf serum (FCS) and plated in
a 96-well tissue culture plate in RPMI + 10% FCS, 10mM
30 L-GLN, 10mM Sodium pyruvate, IL-2, gentamicin. Cells
are refluxed every 24 hours with complete media
containing replacement drug and IL-2. Seven days after

1 infection, samples are taken for the reverse
transcriptase assay. These samples are frozen at -70°C
until analysis.

The procedure for measuring RT (reverse
5 transcriptase) activity can be routinely performed by
one of ordinary skill. Briefly, 50 μl of HIV culture
supernatant are mixed with 50 μl of a 2X RT assay buffer
containing Tris, 0.1M, pH 7.9, KCl, 0.32M, dithiothrei-
10 tol, 0.012M, MgCl_2 , 0.012M, reduced glutathione, 1.2 mM,
ethylene glycol-bis(beta-aminoethylether)-N,N,N',N'-
tetraacetic acid, 1mM, ethylene glycol, 4%, sterile,
distilled water, 10 μl , Triton X-100, 0.2%, template
primer poly(rA).p(dT), 1 $\mu\text{g}/\text{ml}$, 0.05 $\mu\text{g}/\text{sample}$,
(Pharmacia), and 10 $\mu\text{Ci}^3\text{H-dTTP}$ (Amersham). Samples are
15 incubated for 24 hours at 37°C in microtiter plates,
after which the reaction is stopped with 200 μl cold 10%
tetrachloroacetic acid containing 0.2 M sodium PPI. The
plate is then allowed to incubate for 2 hours on ice,
after which, samples are harvested onto DE-81 filter
20 paper discs (Whatman) using a cell harvester. The discs
are washed 8 times in 5% trichloroacetic acid and
absolute ethanol, dried and placed into glass
scintillation vials. They are then counted on a beta
scintillation counter. Negative (uninfected cell
25 supernatants are used to determine the background DNA
polymerase activity, if any) and known positive controls
are assayed simultaneously. Results measured in counts
per minute (cpm) are plotted as % of the control (i.e.,
cpm obtained without drug present but with virus
30 infection) as shown in Figure 4.

1 Figure 4 shows that the IC₅₀ of AC2 is ~4 μ M
and the IC₅₀ of 12MO is ~12 μ M in this reverse
transcriptase assay.

5 Drug cytotoxicity using MTT assay (calculation of TC₅₀)

MT4 cells were plated in 96-well microtiter
plates at 8×10^4 cells/well in a volume of 90 μ l.
[Note: To compare TC₅₀ to IC₅₀, the same cell type used
in antiviral assays was tested in the MTT assay; for
10 these experiments, MT4 cells were used to evaluate the
syncytial cell assays and PBMC's were used to compare
the PBMC/RT assay]. To this was added one minimum
cytotoxic dose of HIV in a volume of 10 μ l. The test
drug was added in 100 μ l aliquots at several concentra-
15 tions. A control plate using uninfected MT4 cells was
set up simultaneously to assess cytotoxicity due to the
drug alone. The plates were then incubated for five
days at 37°C. Then the media was aspirated from the
wells and replaced with 100 μ l MTT solution (3-(4,5-
20 dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide,
1mg/ml in PBS) and incubated for 4 hours at 37°C. The
plates were then centrifuged to pellet the cells, and
the supernatants were removed (centrifugation can be
omitted if the supernatants are removed carefully).
25 Acidic isopropanol (0.04N HCl in isopropanol), 100 μ l,
was then added to the wells and shaken for 15-30 minutes
to dissolve the formazan crystals. Plates were read on
an ELISA reader at Abs 570 nm. The difference between
the uninfected and infected plates represent the
30 antiviral activity of the drug. This assay was used to
determine drug toxicity alone. A similar method has

- 1 been described in the AIDS Research and Reference
Reagent Program Courier, 90-01:8-9, 1990.

Figure 5 shows the results of a typical
experiment run in MT 4 cells which can be compared
5 directly to the syncytial cell assay shown in Figure 3
because the same cell line was used. The TC50 of AC2
was 280 μ M and the TC50 of 12MO was 140 μ M as shown in
Figure 5.

10 Therapeutic Index of Lipids having anti-HIV-Activity

Table 1 summarizes the data shown in Figure 1-
5 by comparing the therapeutic index for 12MO and AC2.
The therapeutic index compares the toxic dose (TC50) to
the effective dose (IC50). The therapeutic index values
15 given in Table 1 are calculated from toxicity data and
activity data that were obtained in the same cell line.
In syncytial cell assays using MT 4 cells the
therapeutic index for AC2 is 280 whereas for 12MO the
therapeutic index is only 35. In PBMC's, the
20 therapeutic index for AC2 is 31 whereas for 12 MO the
therapeutic index is 37.

Moreover, L-AC2 was significantly more potent
than 12MO in HIV infected monocyte-derived macrophages
(MDM) shown in Figure 1. During a 15 day acute
25 infection, L-AC2 at 1 μ M completely suppressed the HIV
infection in MDM yet 12MO had little activity at doses
from 1 to 50 μ M. However, the 100 μ M dose of 12MO
suppressed HIV replication in MDM which demonstrates
that 12MO exhibited a very steep dose response effect in
30 MDM i.e., little activity at 50 μ M and virtually 100%
activity at 100 μ M. No dose response was observed in

1 MDM for L-AC2 because the lowest dose of L-AC2 tested (1
μM) completely inhibited the HIV infection in MDM.

In HIV infected MDM, L-AC1 exhibited dose
responsive activity and 50 μM L-AC1 completely
5 suppressed HIV p24 antigen production; this dose of L-
AC1 had little activity in CEM cells using a direct
cytopathic assay (Figure 1). Diacylated phospholipids
form liposomes, and as expected both L-AC1 and L-AC2
formed liposomes in aqueous buffers. The increased
10 activity of L-AC1 in MDM compared to CEM cells may be
due to the phagocytosis of L-AC1 liposomes in MDM.

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Table I. IC₅₀ and Therapeutic Index of L-AC2 and 12MO

	TC ₅₀	IC ₅₀ (b)	Therapeutic Index (a)	IC ₅₀ (b)	Therapeutic Index (a)
	Cytotoxicity (a) MTT Assay	50% Reduction in syncytial cell formation MT4 cells (a)	MT4 cells	50% Reduction in Reverse Transcriptase Activity PBMC (a)	PBMC
	μM	μM		μM	
12 MO	140 (MT4 cells)	4	35		
	340 (PBMC cells)			19	17
L-AC2	280 (MT4 cells)	1	280		
	220 (PBMC cells)			6	37

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- 1 a) Drug cytotoxicity in the absence of HIV was
determined using MT4 cells or PBMC's. The TC_{50} is the
concentration of the drug that killed 50% of the cells
during a 4 hour incubation period.
- 5 b) The IC_{50} is the drug concentration that inhibited
50% of the maximum HIV response which was observed when
no drug was present. The HIV responses that were
measured are syncytial cell formation of reverse
transcriptase activity.
- c) The therapeutic index was calculated as TC_{50}/IC_{50} .
- 10 d) Syncytial cell assays were performed using MT4 cells
infected with HIV and SupT1 cells as target cells. MT4
cells are CD4+ and highly susceptible to HIV infection.
- e) Drug activity was determined in PBMC by measuring
inhibition of reverse transcriptase activity.

15 Compounds of the present invention (IV, V,
VI), especially those containing at least one heteroatom
fatty acid acyl chain, exhibit synergistic effects when
administered with AZT. The more preferred embodiments
(compounds of formulae VIII-XV) also exhibit this
20 effect. An illustrative example is given hereinbelow.

Synergism of AC2 with AZT

Another set of data demonstrates the synergism
observed with AC2 and AZT in syncytial cell assays using
25 T cells.

12MO has been reported to act synergistically
when administered concurrently with AZT, and the
synergism between AZT and either 12MO or L-AC2 using
syncytial cell assays was evaluated. (Figure 6). The
30 dose response curves for each drug alone shows that AZT
is ~100 times more potent than L-AC2; however, AZT is
~ 10^3 to 10^4 times more potent than 12MO. Synergism was

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1 evaluated by the shift in the dose response curves when
0.5 nM AZT (an inactive concentration) was added to 12MO
and L-AC2; 12MO exhibited less than a factor of 10
increase in activity whereas L-AC2 exhibited
5 approximately 100 fold increased activity (Figure 6).
For instance, Figure 6 shows that 5 nM L-AC2 (an
inactive concentration labelled ** in Figure 6) and 0.5
nM AZT (an inactive concentration) exhibited ~50%
inhibition of syncytia formation in HIV infected MT4
10 cells. Figure 6 also shows that 10 nM L-AC2 (an
inactive concentration) shifts the dose response curve
of AZT approximately 100 fold. Using MT4 cells,
concentrations of AZT from 50 nM to 500 nM did not alter
the concentration of L-AC2 that killed 50% of uninfected
15 cells, i.e., the TC_{50} of L-AC2 is unchanged in the
presence of AZT.

Figure 6 clearly shows the increased
synergistic effects of L-AC2 with AZT as compared with
12MO and AZT. Without wishing to be bound, it is
20 believed that the synergism for L-AC2 and AZT is not due
to increased cellular toxicity from administering both
drugs concurrently; it is believed that the synergism is
due to direct inhibition of HIV by two different
mechanisms. AZT is a reverse transcriptase inhibitor;
25 whereas, L-AC2 putatively inhibits endogenous
myristoylation of the HIV proteins.

Anti-HIV Activity of D-AC2

L-AC2 contains the natural configuration of
30 glycerophosphocholine and is quantitatively hydrolyzed
by bee venom phospholipase A2 (PLA2) within minutes.
PLA2s stereospecifically hydrolyze phospholipids.

1 However, the D-isomer, i.e., D-AC2 was prepared to test
the hypothesis whether endogenous PLA2s are responsible
for 12MO release from phosphatidylcholine analogs
containing 12MO. Figure 7 shows that the IC_{50} for D-AC2
5 is ~ 1 uMolar which is identical to the IC_{50} of L-AC2.
Unlike L-AC₂, D-AC2 is not hydrolyzed by PLA2.

Figure 7 also shows the anti-HIV activity of
the phosphatidylethanolamine (PE) analogs L-PE1 and L-
PE2; these analogs are chemically similar to L-AC1 and
10 L-AC2 respectively except the PC headgroup has been
changed to the PE headgroup. The IC_{50} of L-PE1 and L-
PE2 are 6 uMolar and 0.02 uMolar respectively; compared
to the PC analogs this is approximately a 20-50 fold
increase in activity. The anti-HIV activity of L-PE2 is
15 > 100 fold more than 12MO (Figure 7).

Stability of Anti-HIV Phospholipids in Fresh Blood
at 38°C

Drug development using phospholipids will
20 require that the parent compound is stable in blood.
Figure 8 shows that the halflife of L-AC2 in fresh blood
is 4.56 hours and the halflife of D-AC2 is 18.24 hours
(~ 4 times longer). Thus, by changing the
stereochemistry of the glycerobackbone to the unnatural
25 configuration the halflife in blood can significantly be
increased. Changing the lipid headgroup also increases
the stability in blood. L-PE2 has a halflife in fresh
blood of 9.36 hours which is approximately 2 times
longer than L-AC2 (Figure 8). It was very surprising
30 that L-PE1 has a very long halflife ($T_{1/2} > 50$ hours)
compared to the L-PE2. L-PE1 and L-PE2 are identical
except that the methylene group in the 13 position of

- 1 the sn-2 alkyl chain has been replaced with an oxygen atom.

Without wishing to be bound, it is believed that the increased activity, particularly of L-AC2 and
5 L-PE2 compared to 12MO, and also the increased synergism of L-AC2 with AZT compared to 12MO and AZT is due to the cellular disposition of phospholipid analogs. When 12MO is delivered to cells as a free fatty acid it is rapidly incorporated into triglycerides and membrane lipids.
10 The $T_{1/2}$ for incorporation is approximately 1-2 minutes. Triglycerides are usually thought of as storage depot for fats that are used as a source of energy. If intracellular triglycerides containing 12MO are used primarily as an energy source instead of a source of
15 fatty acids for myristoylation of HIV proteins, then this may be the primary reason why the cellular availability, necessary for anti-HIV activity, of 12MO is 10 fold or 100 fold less than L-AC2 and L-PE2. Thus lipid metabolism and the intracellular disposition of
20 hetero atom fatty acids and anti-HIV phospholipids can significantly affect anti-HIV activity.

The data in the figures and the Table clearly illustrate that acylation of a drug containing a carboxy group to the hydroxy group of the glycerol backbone of a
25 phospholipid significantly enhances the pharmacokinetics of said drug. The phospholipid drug has an increased therapeutic index relative to the non-phospholipid drug. The phospholipid drugs prepared in accordance with the present invention can be more potent (Figure 1), less
30 toxic (Figure 1), and more stable (Figure 8), and can have increased availability or distribution relative to the non-phospholipid drug. The enhanced pharmacokinetics

1 of the phospholipid drugs prepared in accordance with
the present invention makes it an extremely powerful
weapon in the war against diseases.

The foregoing description of the invention has
5 been presented for purposes of illustration and
description and is not intended to be exhaustive or to
limit the invention to the precise form disclosed.
Other variations are possible in light of the teachings
presented herein.

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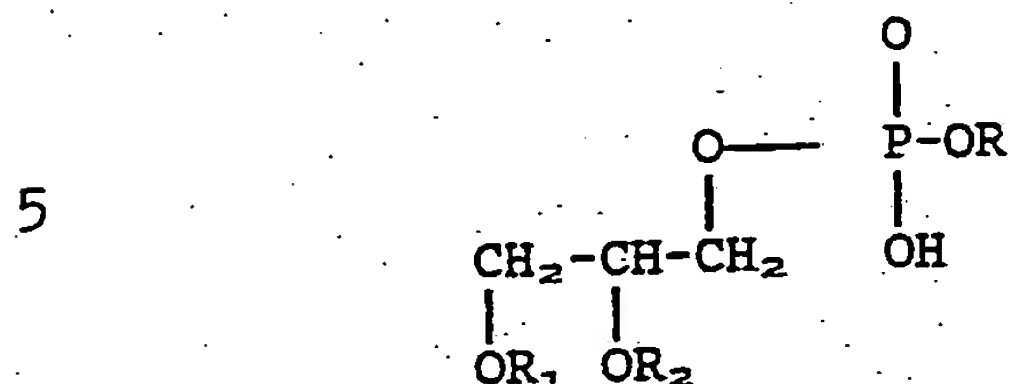
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1 WHAT IS CLAIMED IS:

1. A compound of the formula



or pharmaceutically acceptable salts thereof

wherein

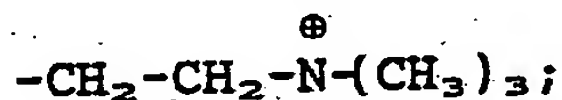
10 one of R_1 and R_2 is a heteroatom fatty acid acyl group having 13-14 carbon atoms in the principal chain and up to a total of 18 carbon atoms, while the other is hydrogen, a heteroatom of fatty acid acyl group containing 13-14 carbon atoms in the principal chain and up to a total of 18 carbon atoms or an acyl group of a

15 fatty acid containing 4-26 carbon atoms in the principal chain and up to a total of 30 carbon atoms and

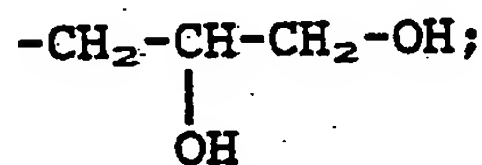
20 R is a naturally occurring polar group characteristic of a glycerolphospholipid isolated from endogenous sources.

2. The compound according to Claim wherein R

is



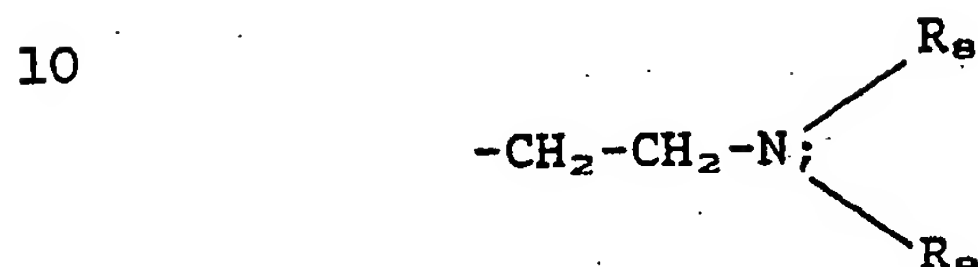
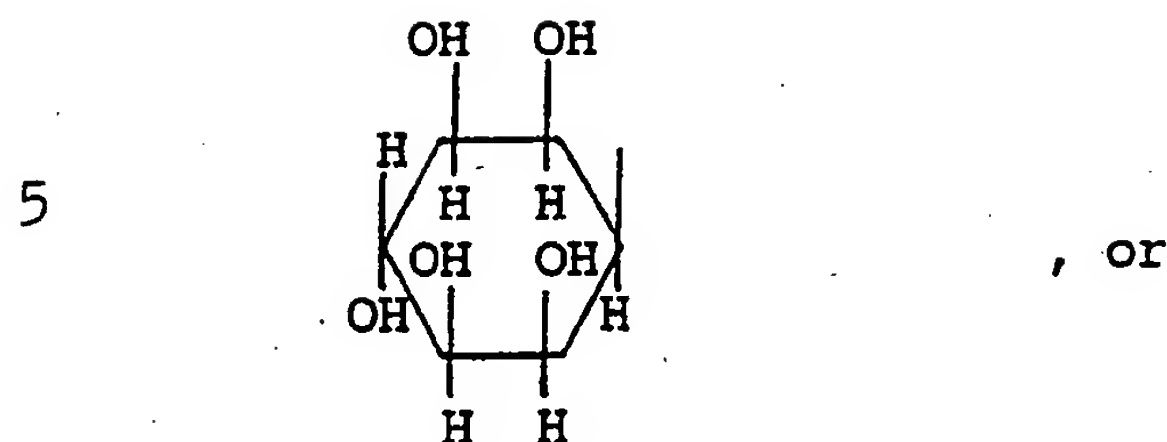
25



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1 -CH₂-CH₂-NH₂, or



15 3. The compound according to any one of Claims 1-2 wherein the acyl group of a fatty acid contains 4-16 carbon atoms.

20 4. The compound according to any one of Claims 1-3 wherein R₁ is a heteroatom fatty acid acyl group and R₂ is hydrogen, a heteroatom fatty acid acyl group or an acyl group of a fatty acid.

5. The compound according to any one of Claims 1-4 wherein R₂ is a heteroatom fatty acid acyl group or hydrogen.

25 6. The compound according to any one of Claims 1-3 wherein R₂ is a heteroatom fatty acid acyl group and R₁ is hydrogen, a heteroatom fatty acid acyl group or an acyl group of a fatty acid containing 4-14 carbon atoms.

30 7. The compound according to any one of Claims 1-3 and 6 wherein R₁ is a heteroatom fatty acid acyl group, hydrogen, or an aryl group of a fatty acid containing 4-14 carbon atoms.

35 8. The compound according to any one of Claims 1-7 wherein R₁ and R₂ are both a heteroatom fatty acid acyl group.

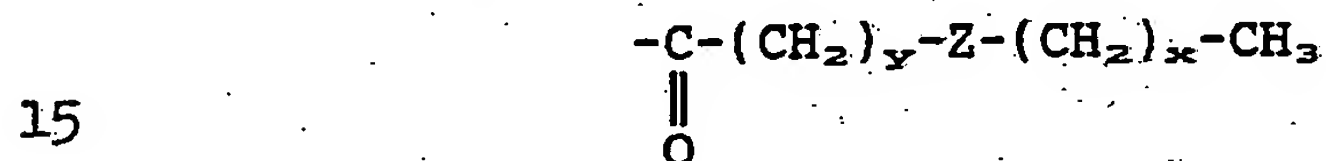
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1 9. The compound according to any one of
Claims 1-8 wherein R_1 is the same as R_2 .

 10. The compound according to any one of
Claims 1-3 wherein R_1 is a heteroatom fatty acid acyl
5 group and R_2 is hydrogen or an acyl group of a fatty
acid containing 4-14 carbon atoms.

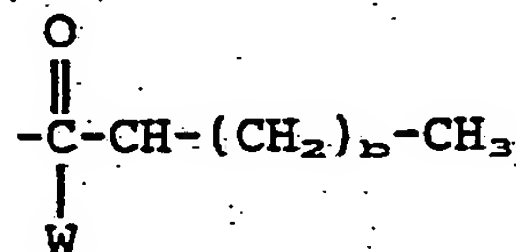
 11. The compound according to any one of
Claims 1-3 wherein R_2 is a heteroatom fatty acid acyl
group and R_1 is hydrogen or an acyl group of a fatty
10 acid containing 4-14 carbon atoms.

 12. The compound according to any one of
Claims 1-11 wherein the heteroatom fatty acid acyl group
has the formula:



wherein x is 0-11 and y is 1-11 and $x+y = 11$ and Z is O
or S.

 13. The compound according to any one of
Claims 1-11 wherein the heteroatom fatty acid acyl group
20 has the formula:



25 wherein W is hydroxy, halo, lower alkoxy, mercapto or
lower alkylthio; and

b is 11.

 14. The compound according to Claim 13 wherein
 W is hydroxy or halo.

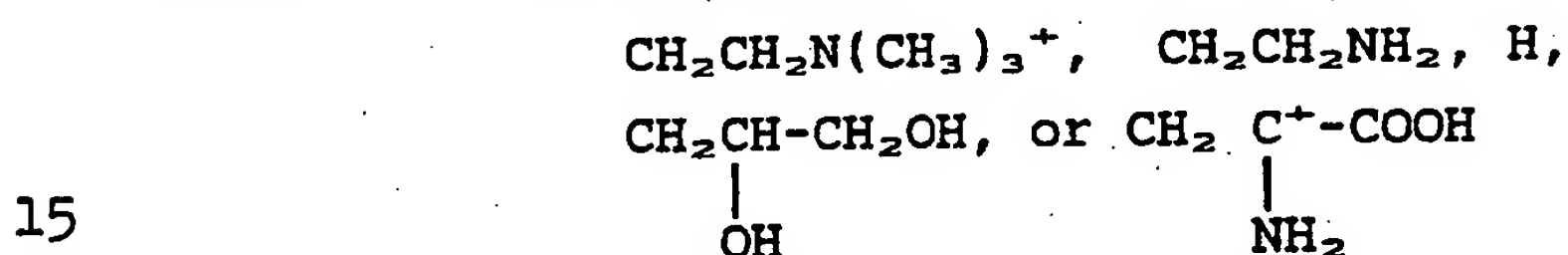
30 15. The compound according to Claim 14 wherein
halo is Br or Cl.

- 1 16. The compound according to any one of
Claims 1-12 wherein the heteroatom fatty acid acyl group
is



17. The compound according to any one of
Claims 1-16 wherein the acyl group of the fatty acid is
10
$$\begin{array}{c} \text{C}(\text{CH}_2)_{12}\text{CH}_3. \\ \parallel \\ \text{O} \end{array}$$

18. The compound according to any one of
Claims 1-17 wherein R is



19. The compound according to any one of
Claims 1-18 wherein R is



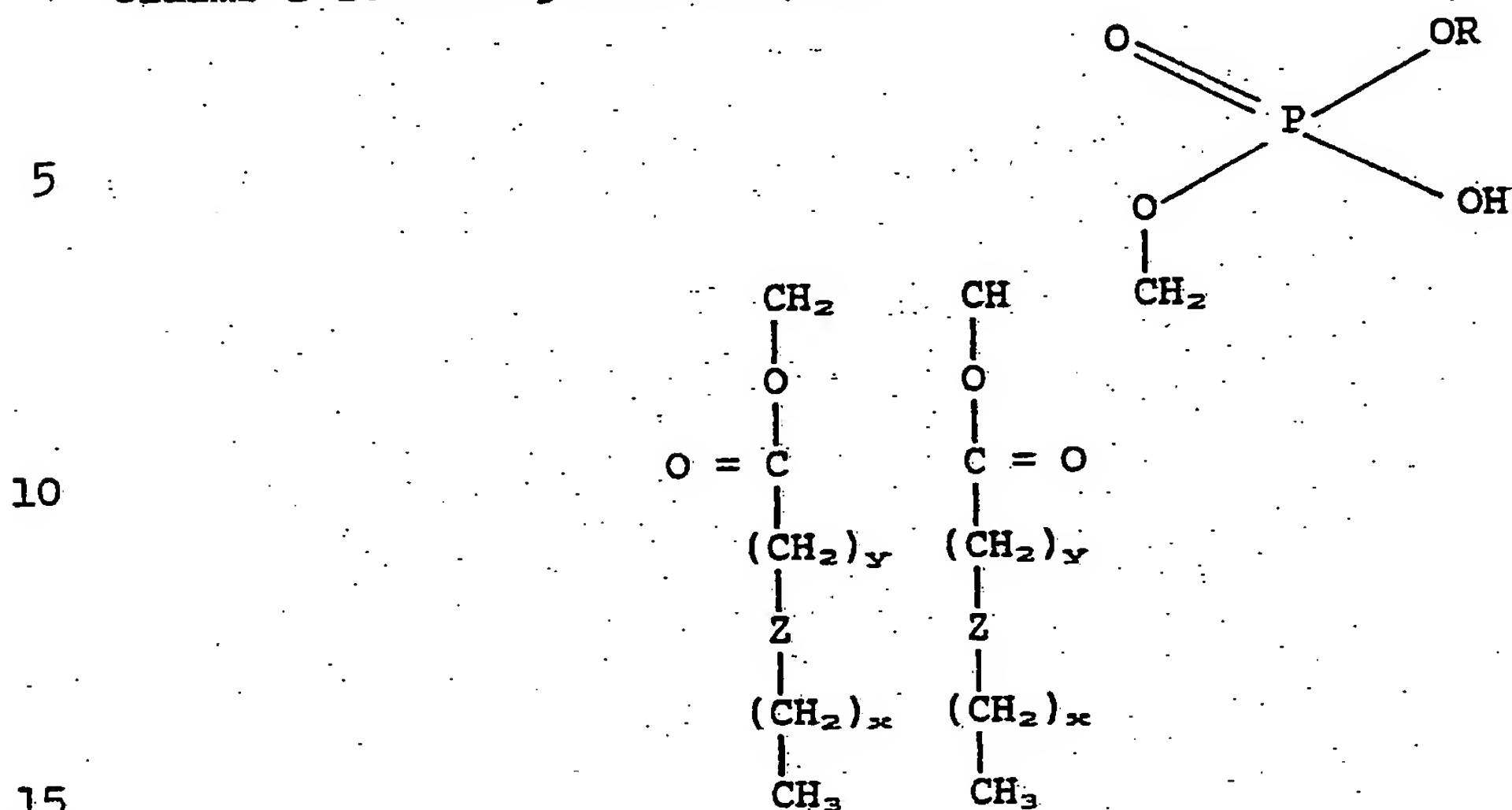
20. The compound according to any one of
Claims 1-19 wherein Z is O.

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- 1 21. The compound according to any one of
Claims 1-20 having the formula:



or pharmaceutically acceptable salts thereof
wherein

20 R is a naturally occurring polar head group
characteristic of a glycerophospholipid isolated from
endogenous sources;

R₁ and R₂ are independently hydrogen or an
alkyl fatty acid acyl group having 4-26 carbon atoms,
and A is a heteroatom alkyl fatty acid acyl group having
25 3-25 carbon atoms

Z is O or S;

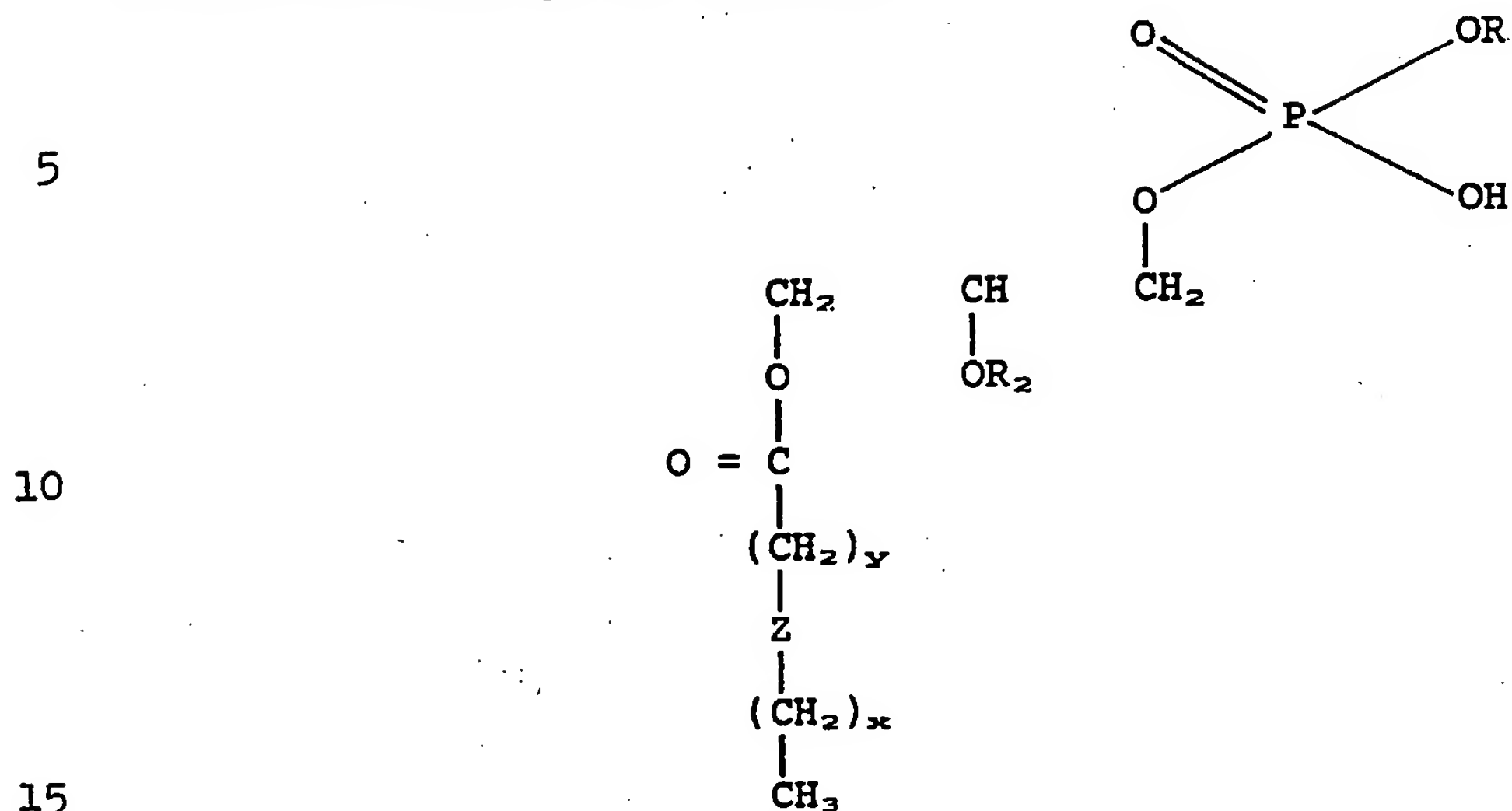
x = 0-11

y = 1-11 and x + y = 11.

30

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- 1 22. The compound according to any one of
Claims 1-20 having the formulae:



or pharmaceutically acceptable salts thereof
wherein

R is a naturally occurring polar head group
characteristic of a glycerophospholipid isolated from
20 endogenous sources;

Z is O or S;

x = 0-11,

y = 1-11, and x + y = 11, and

25 R₁ and R₂ are independently hydrogen or $\text{C} - \text{R}_7$;
 $\begin{array}{c} \text{C} \\ \parallel \\ \text{O} \end{array}$

and

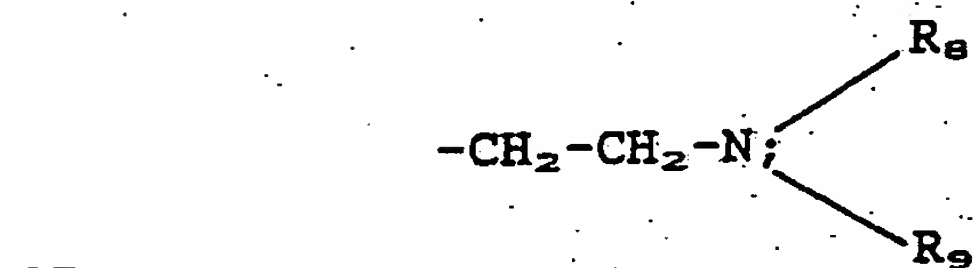
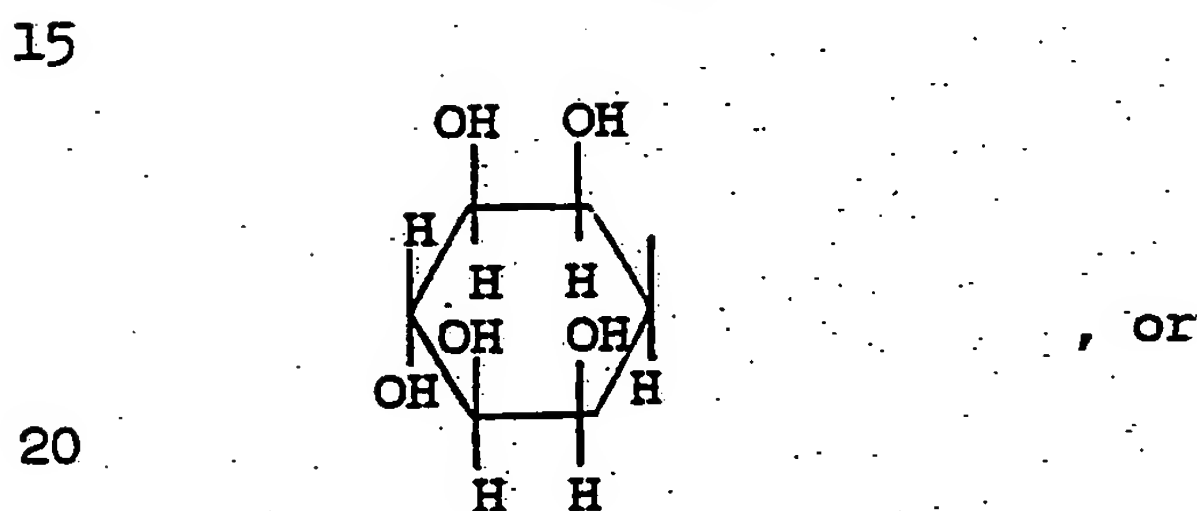
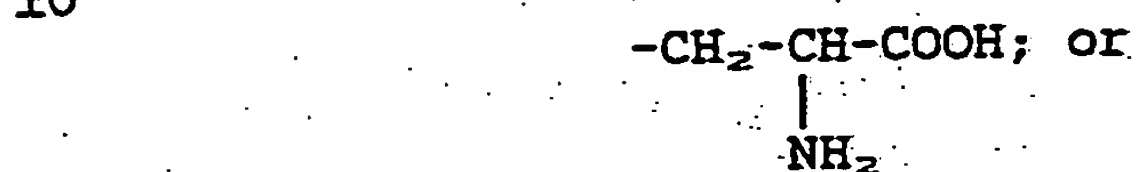
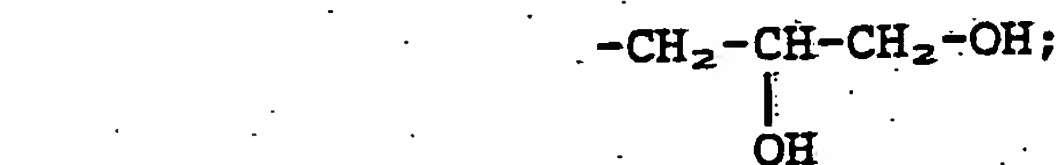
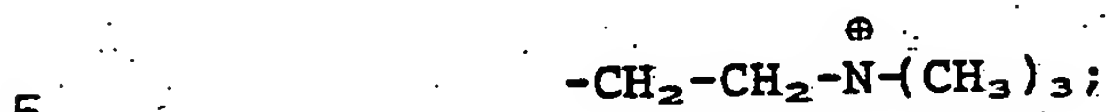
R₇ is an alkyl group containing 3-18 carbon
atoms.

- 30 23. The compound according to Claim 22 wherein
R₇ is an alkyl group containing 13 carbon atoms.

35

1 24. The compound according to any one of
Claims 21-23 wherein

R is



25. The compound according to any one of
Claims 21-24 wherein R is $\overset{\oplus}{\text{CH}_2\text{CH}_2\text{N}}(\text{CH}_3)_3$ or $\text{CH}_2\text{CH}_2\text{NH}_2$.

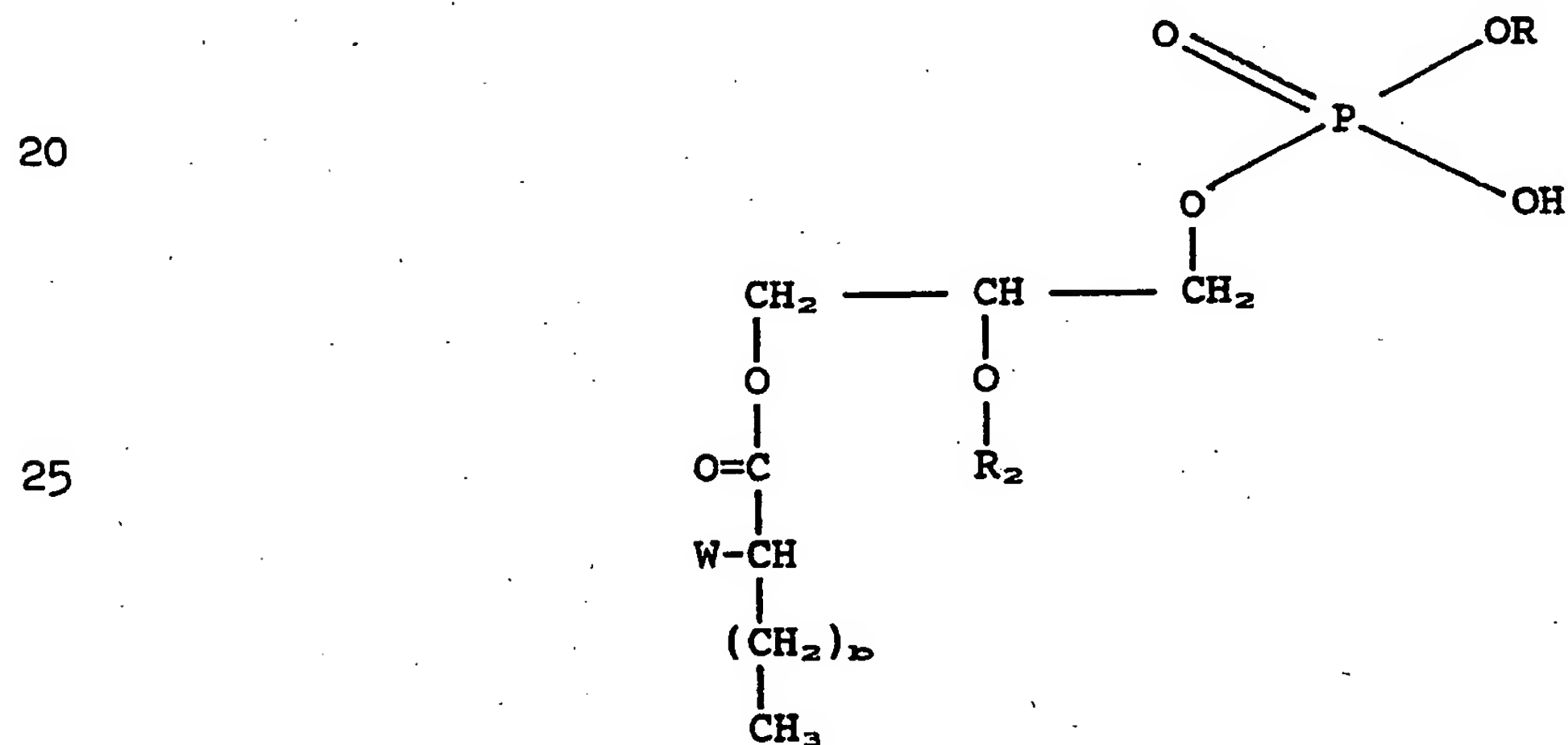
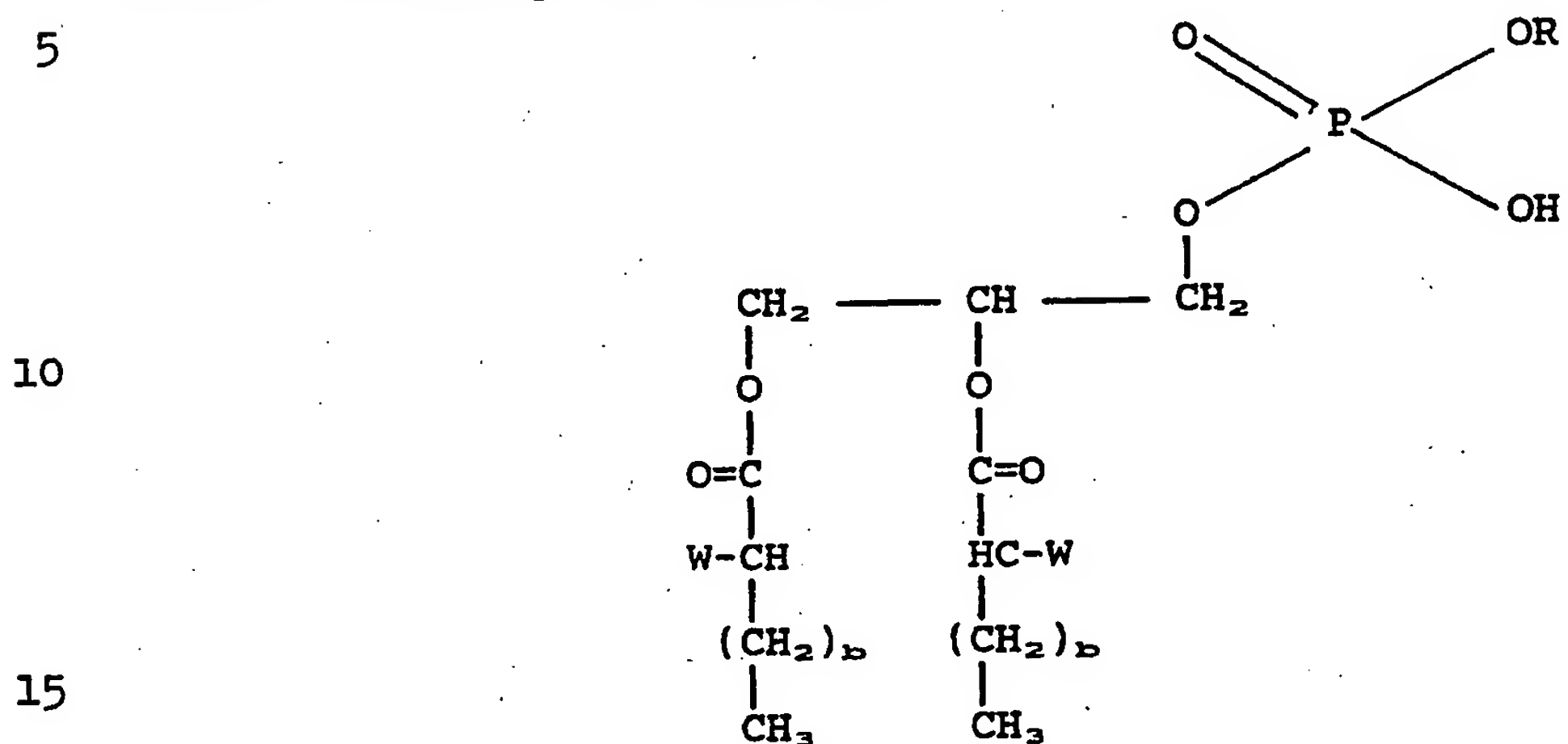
30 26. The compound according to any one of
Claims 21-25 wherein Z is 0.

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1 27. The compound according to any one of
Claims 21-26 wherein x is 0 and y is 11.

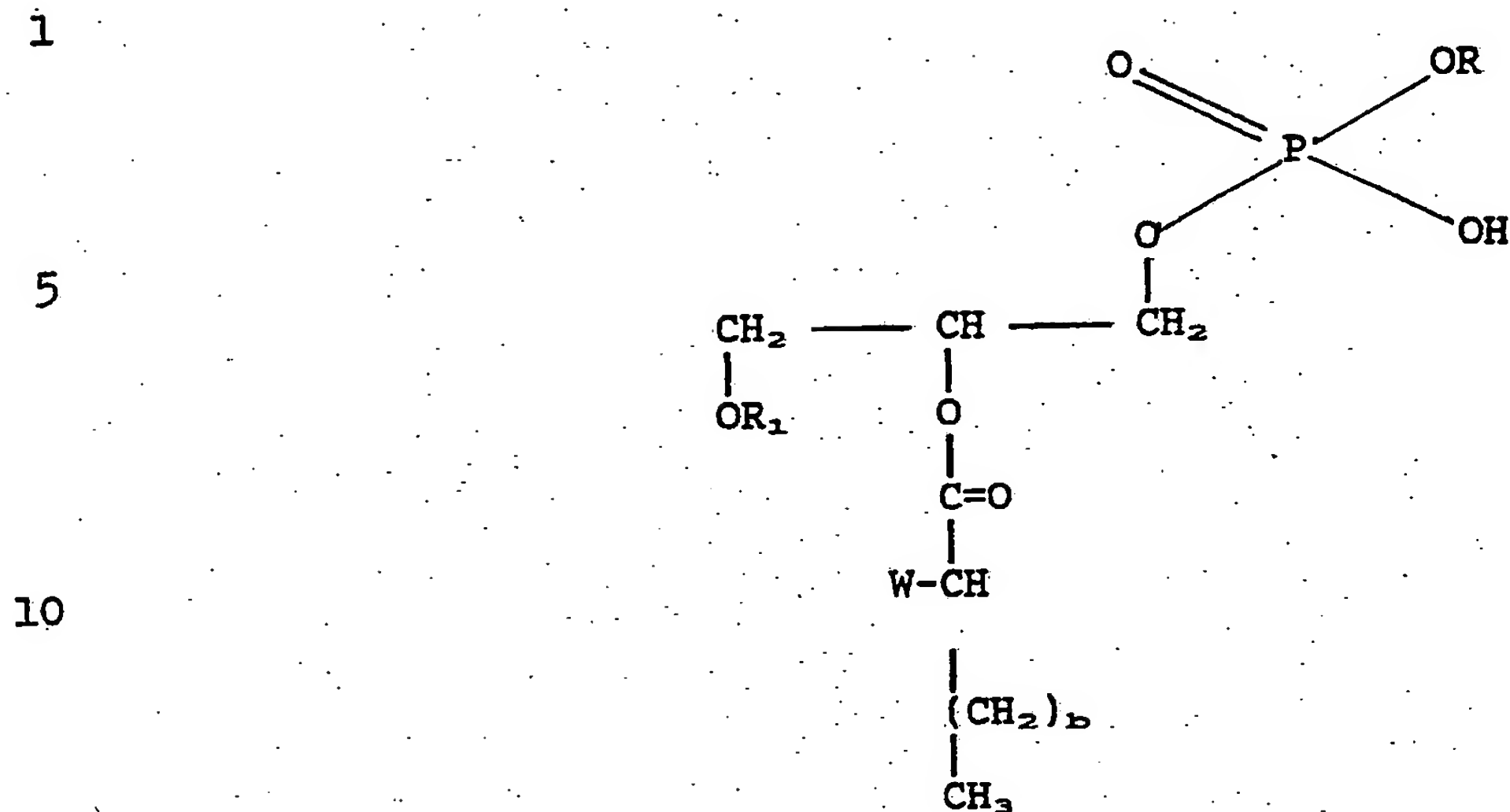
 28. The compound according to any one of
Claims 1-9 having the formulae:



or

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XII

or pharmaceutically acceptable salts thereof
wherein

W is hydroxy, halo, lower alkoxy, mercapto or
lower alkylthio,

b is 11

R is a naturally occurring polar head group
characteristic of a glycerophospholipid isolated from
endogenous sources;

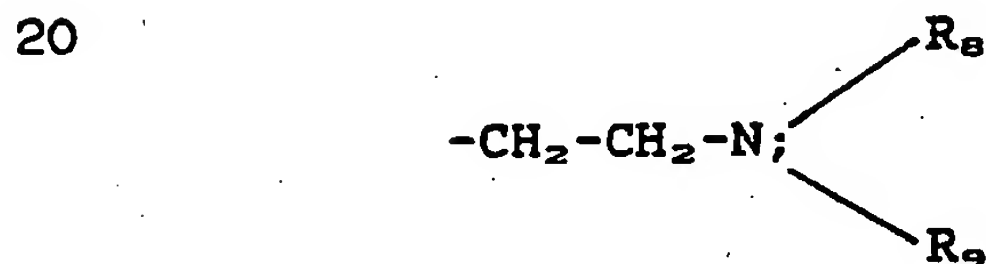
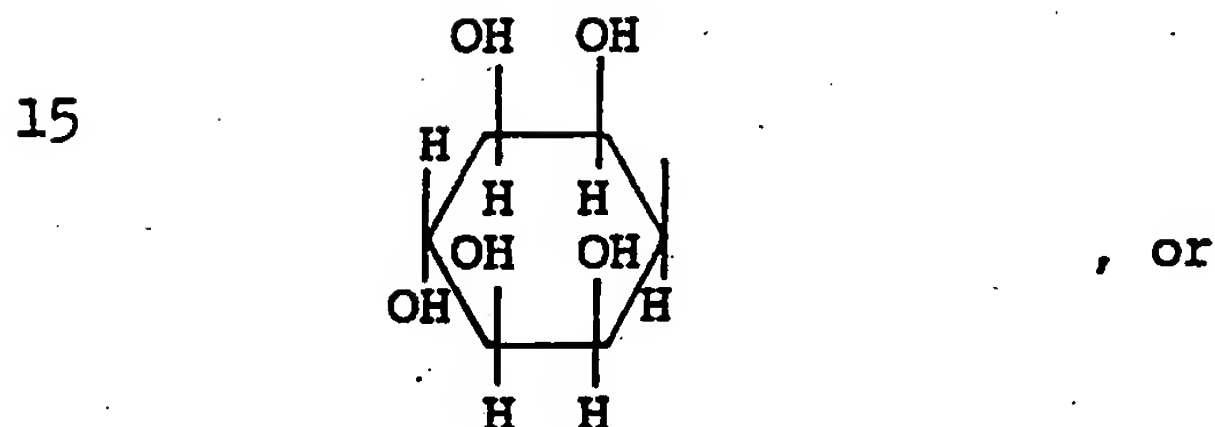
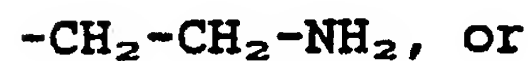
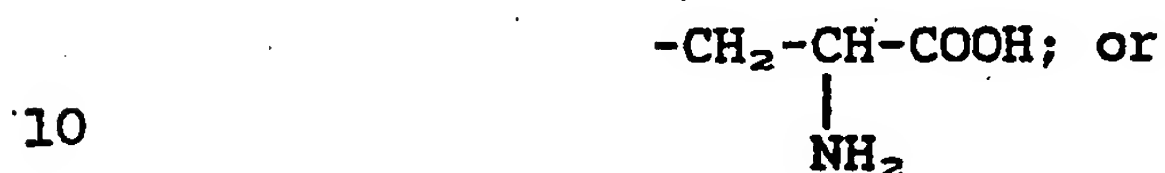
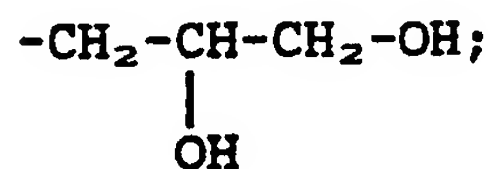
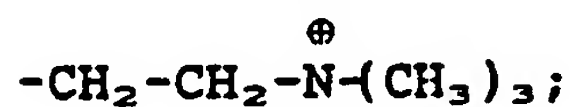
R₁ and R₂ are independently hydrogen or $\text{C} - \text{R}_7$,
 \parallel
 O

R₇ is an alkyl group containing 3-18 carbon
atoms.

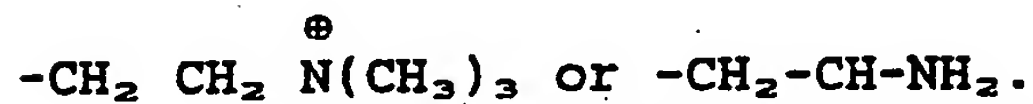
29. The compound according to Claim 28
wherein W is hydroxy or halo.

30. The compound according to Claim 29
wherein halo is Br or Cl.

- 1 31. The compound according to any one of
Claims 28-30 wherein R is

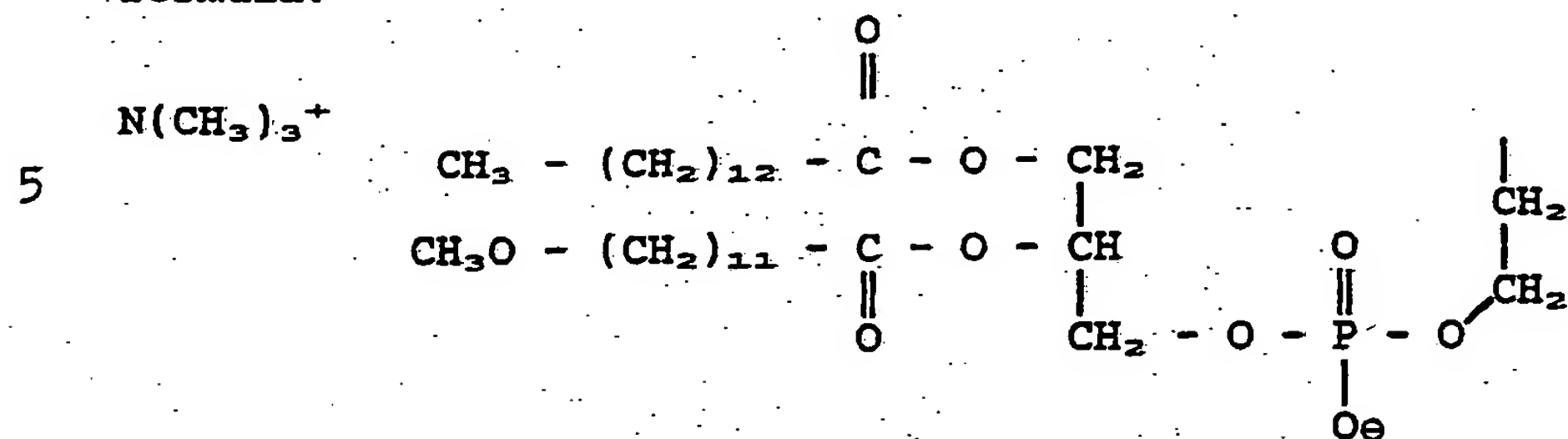


- 25 32. The compound according to any one of
Claims 28-31 wherein R is

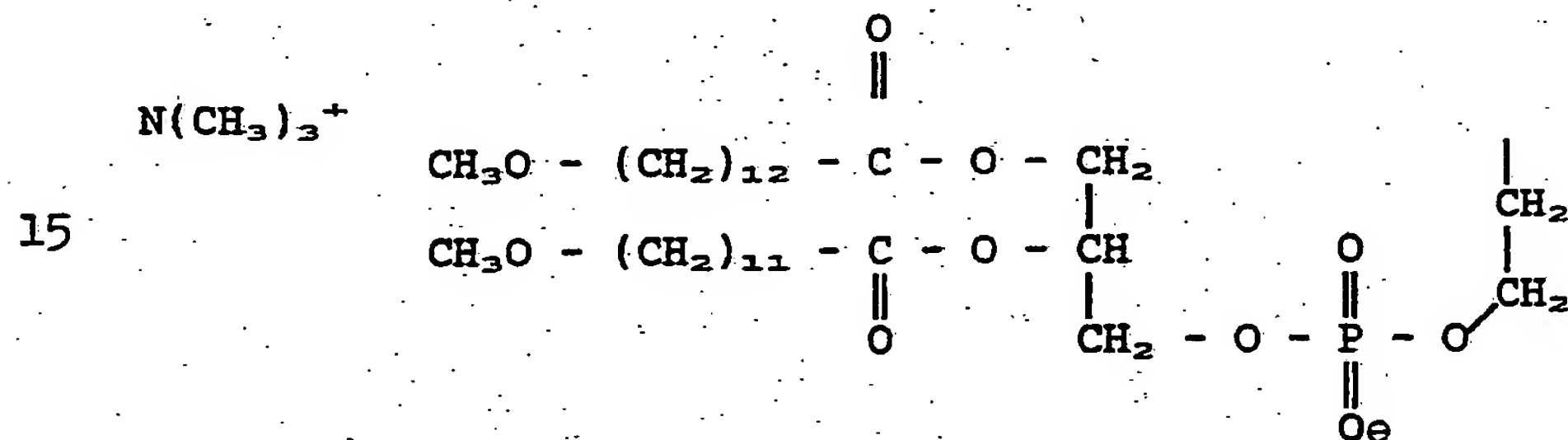


- 30 33. The compound according to any one of
Claims 28-32 wherein R₇ is an alkyl group containing 3-7
or 13 carbon atoms.

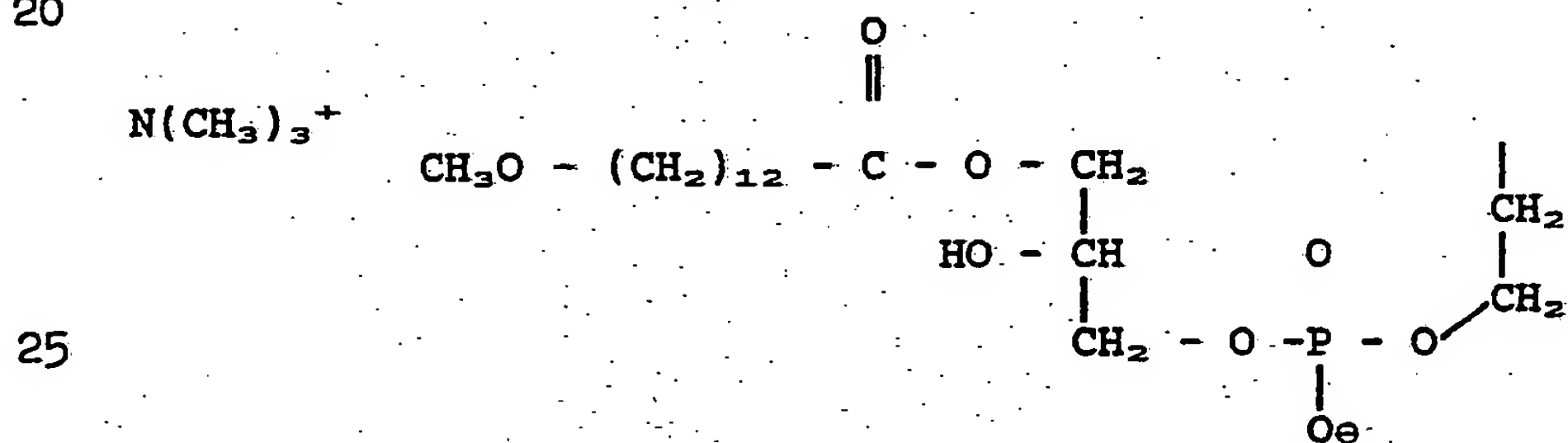
1 34. The compound according to Claim 1 of the
formula:



10 35. The compound according to Claim 1 of the
formula:



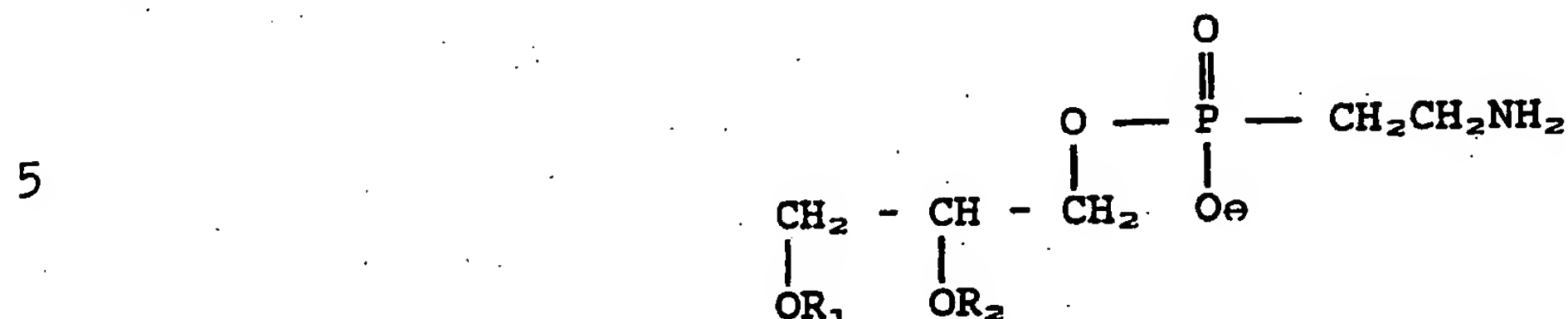
36. The compound of Claim 1 of the formula:



30

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1 37. The compound according to Claim 1 which
 is



 wherein

10 R₁ is myristoyl or 12-methoxydodecanoyl and
 R₂ is 12-methoxydodecanoyl acid.

 38. The compound according to any one of
 Claims 1-37 wherein the configuration at the carbon in
 the Sn-2 position is L.

15 39. The compound according to any one of
 Claims 1-37 wherein the configuration at the carbon in
 the Sn-2 position is D.

 40. A substantially pure compound of any of
 Claims 1-39.

20 41. A method for the inhibition of protein
 myristoylation in animals comprising administering to
 said animal an effective amount of a compound according
 to any one of claims 1-40.

25 42. A method for the inhibition of retroviral
 proliferation in an animal comprising administering to
 said animal a retroviral proliferation inhibiting amount
 of the compound according to any one of Claims 1-40.

30 43. A method for the treatment of AIDS in an
 animal which comprises administering to said animal an
 anti-AIDS effective amount of the compound according to
 any of Claims 1-40.

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1 44. A pharmaceutical composition suitable for
administration to an animal in need thereof comprising a
pharmaceutically acceptable carrier and an effective
amount of a compound according to any one of Claims 1-
5 40.

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FIG. 1a

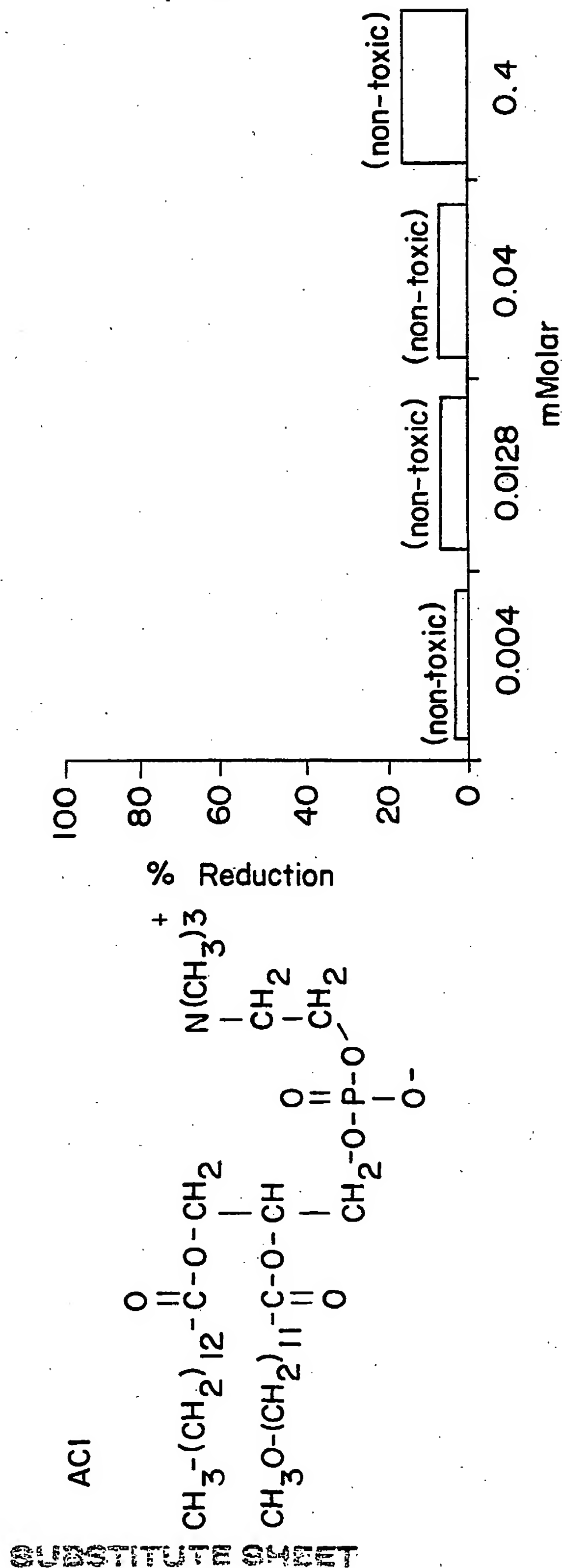


FIG. 1b

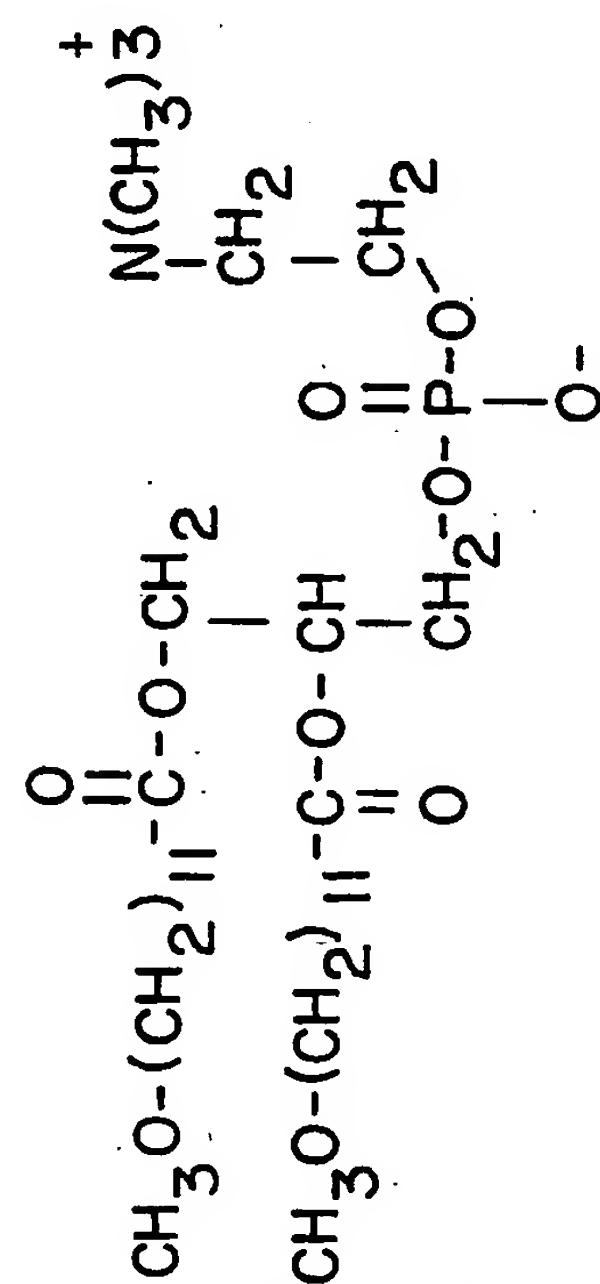
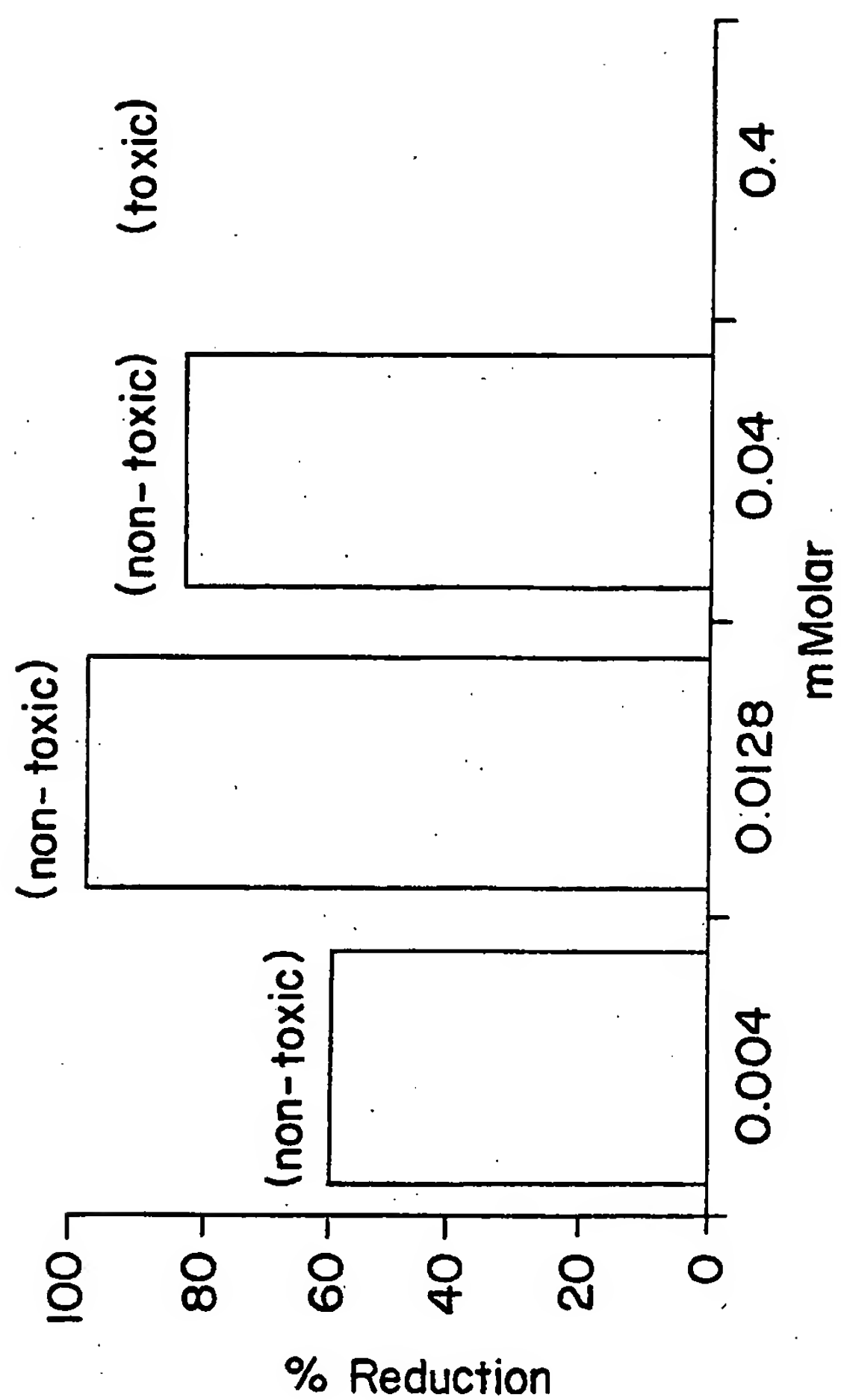
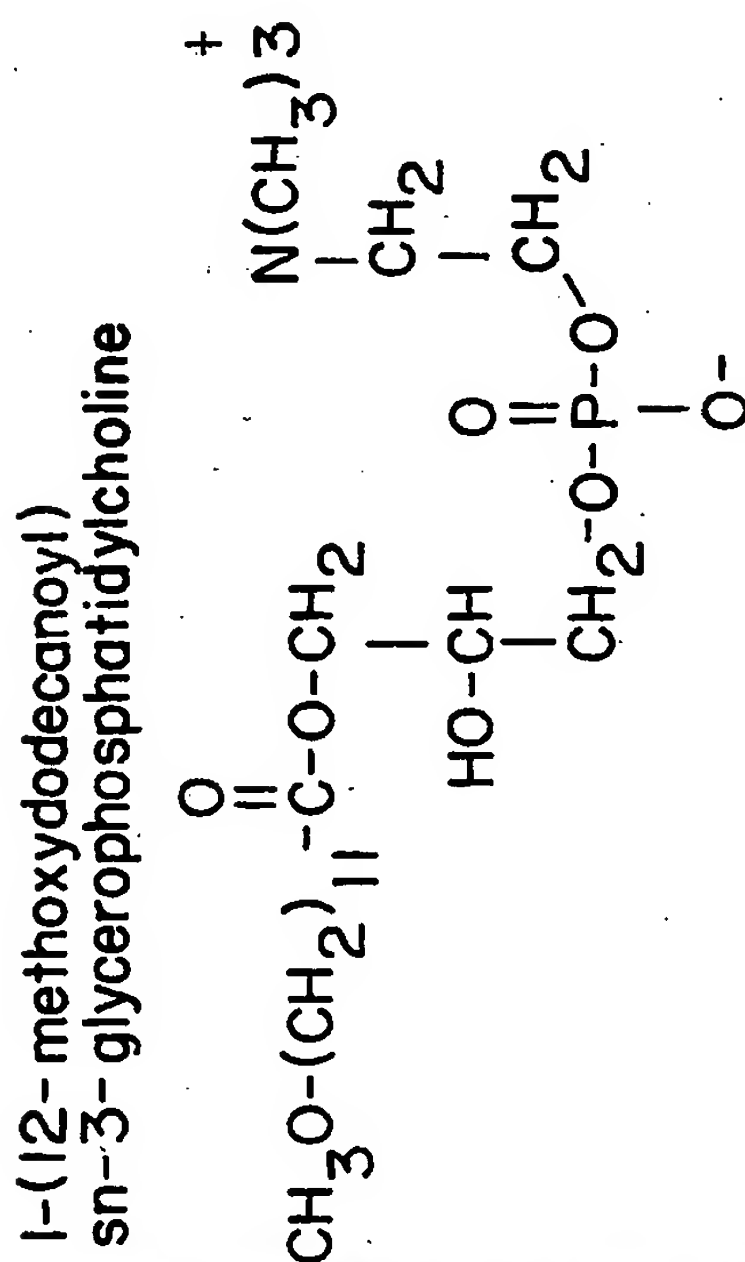
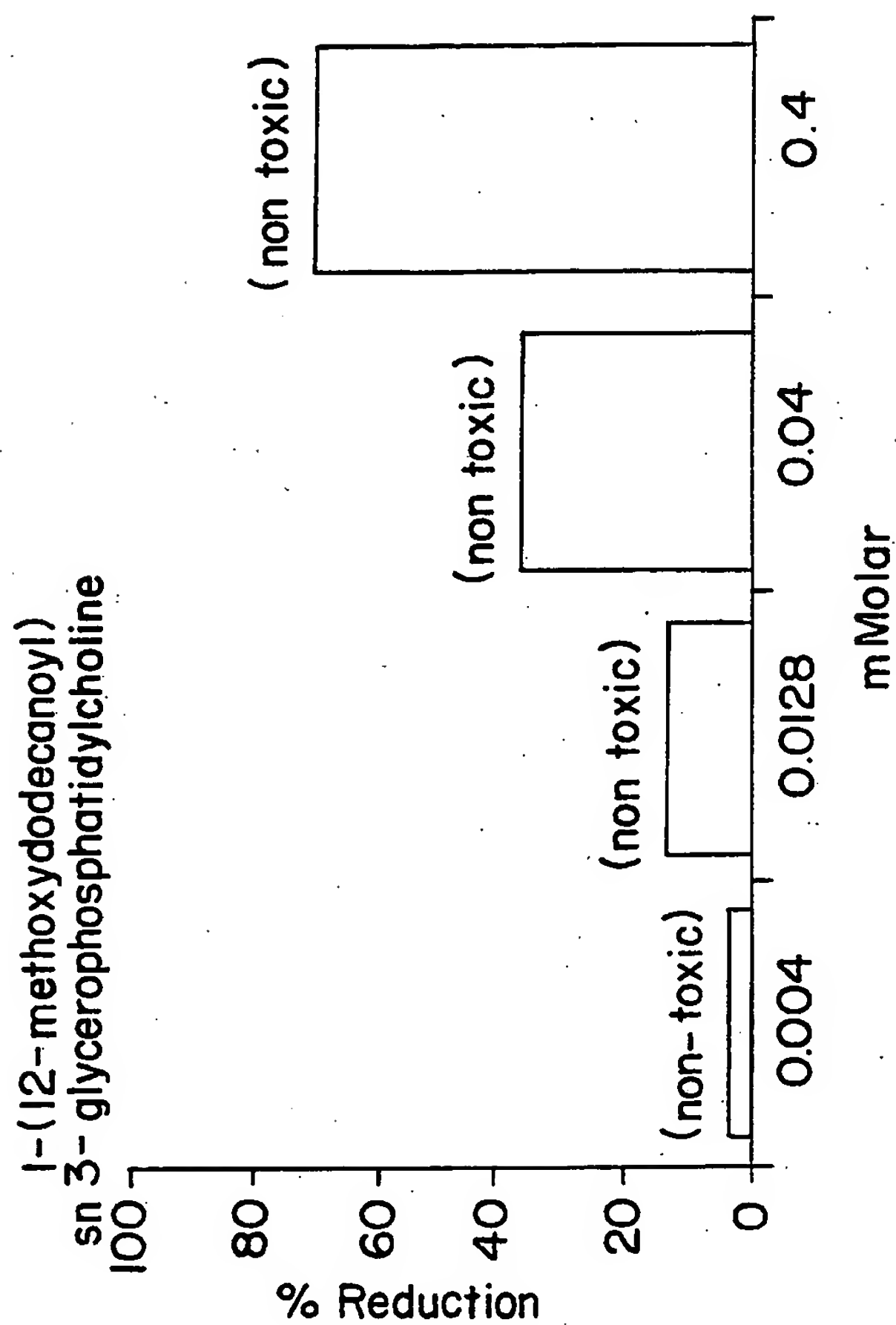
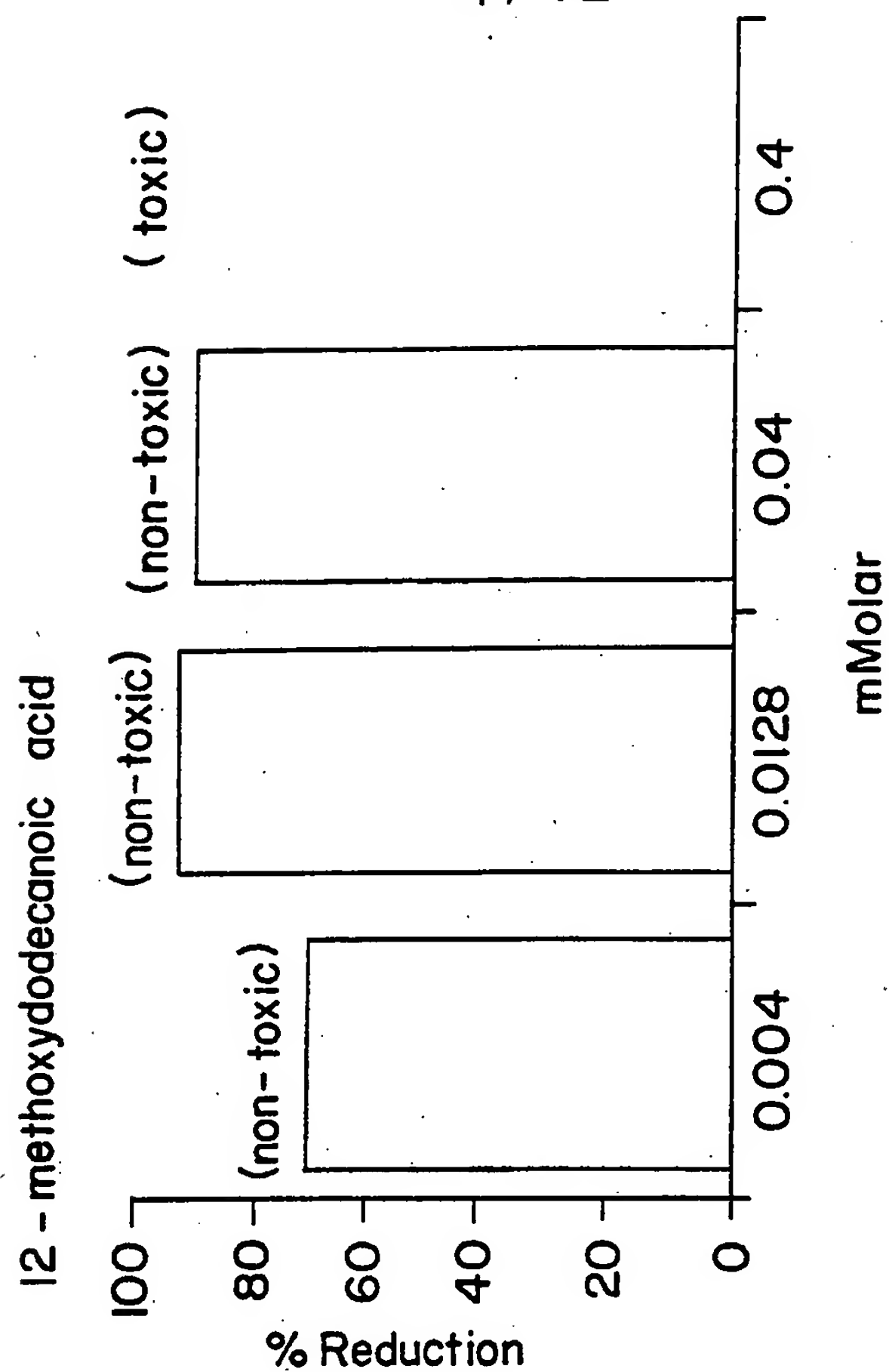


FIG. 1c

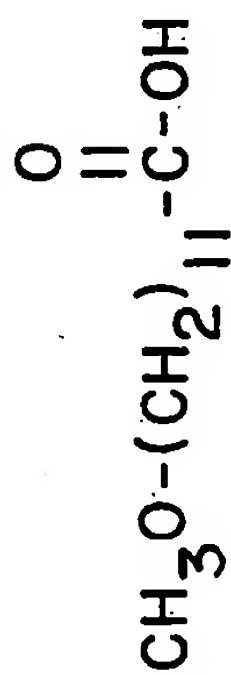


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FIG. 1d



12-methoxydodecanoic acid



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FIG. 2A

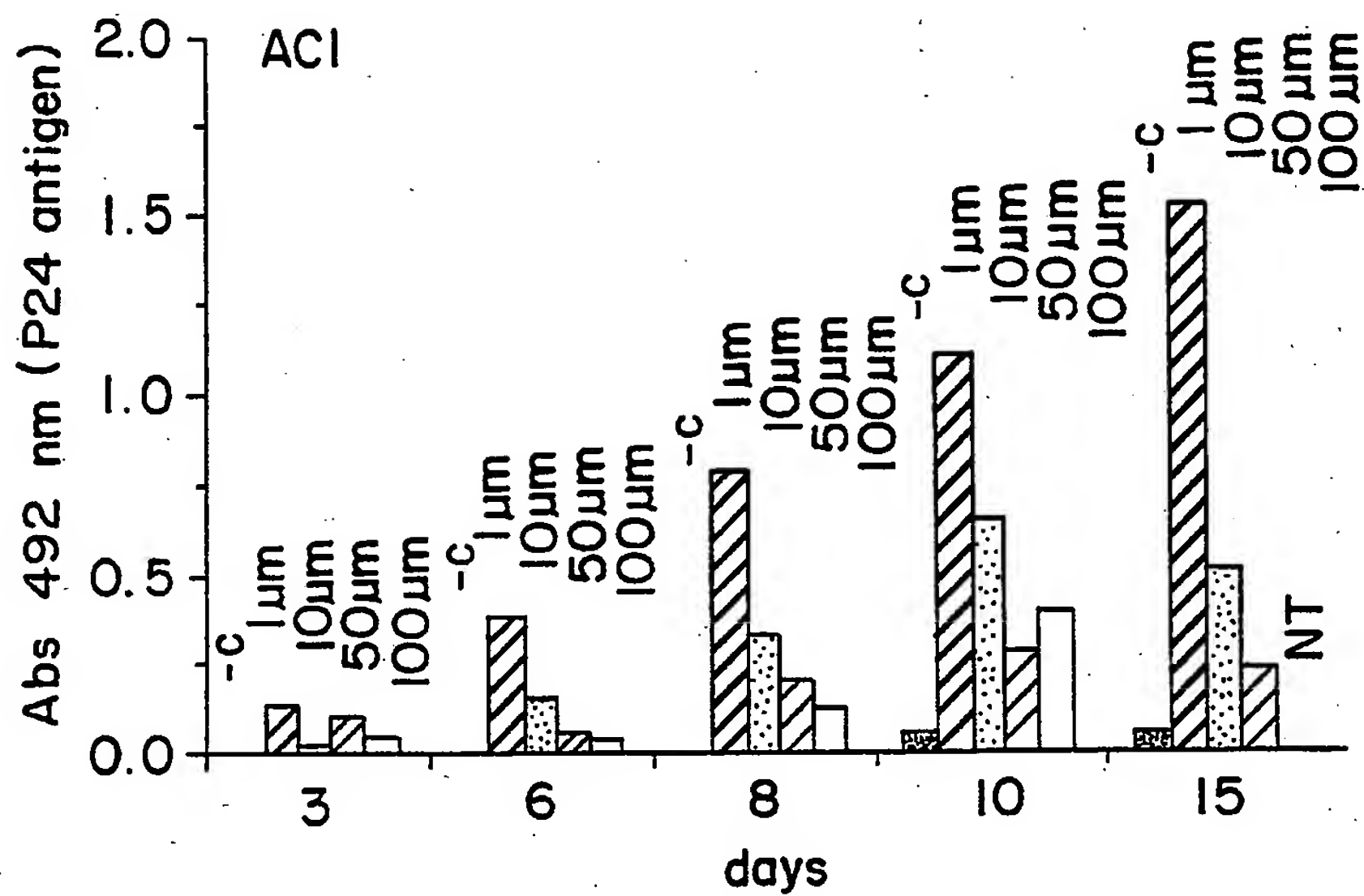
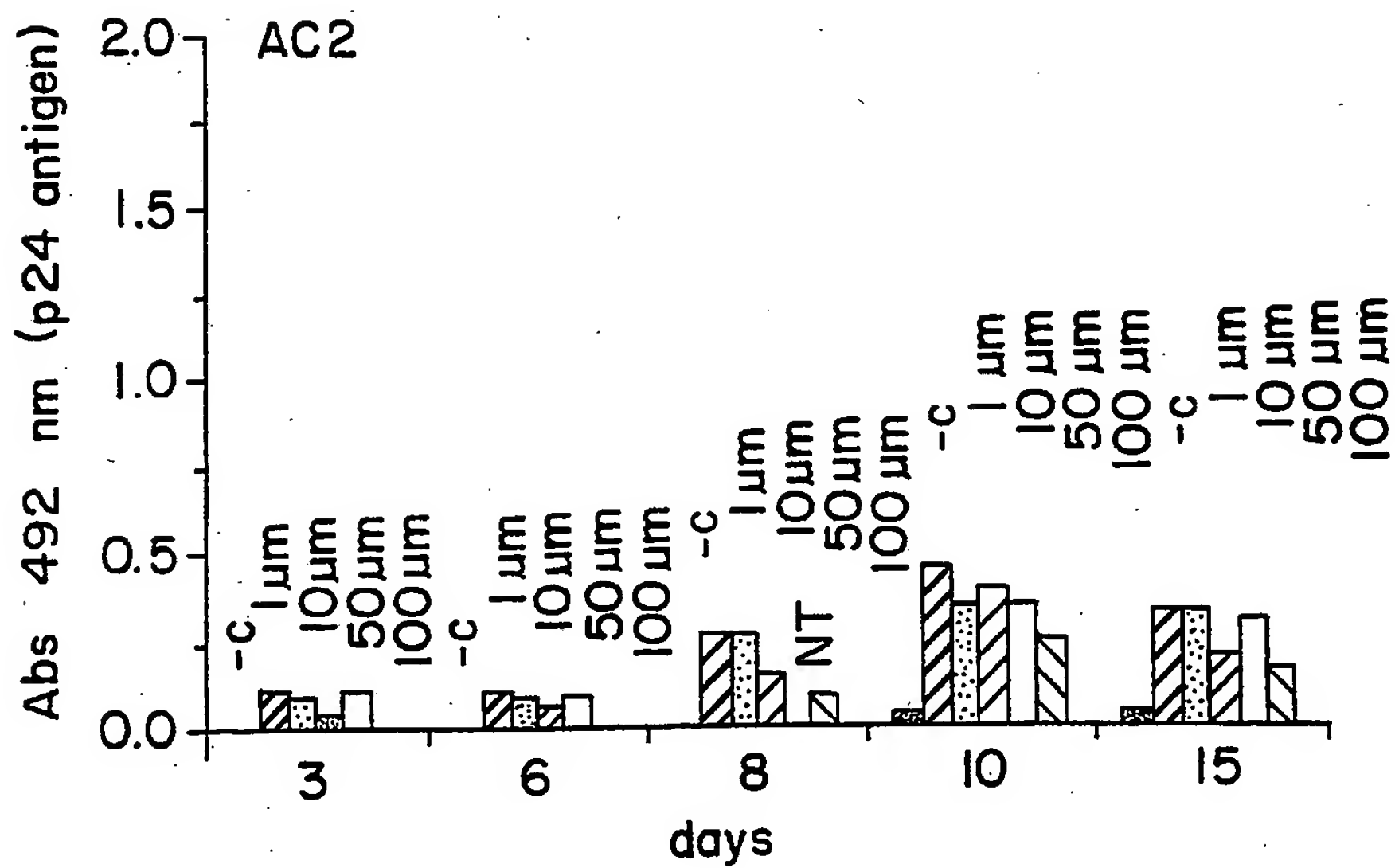


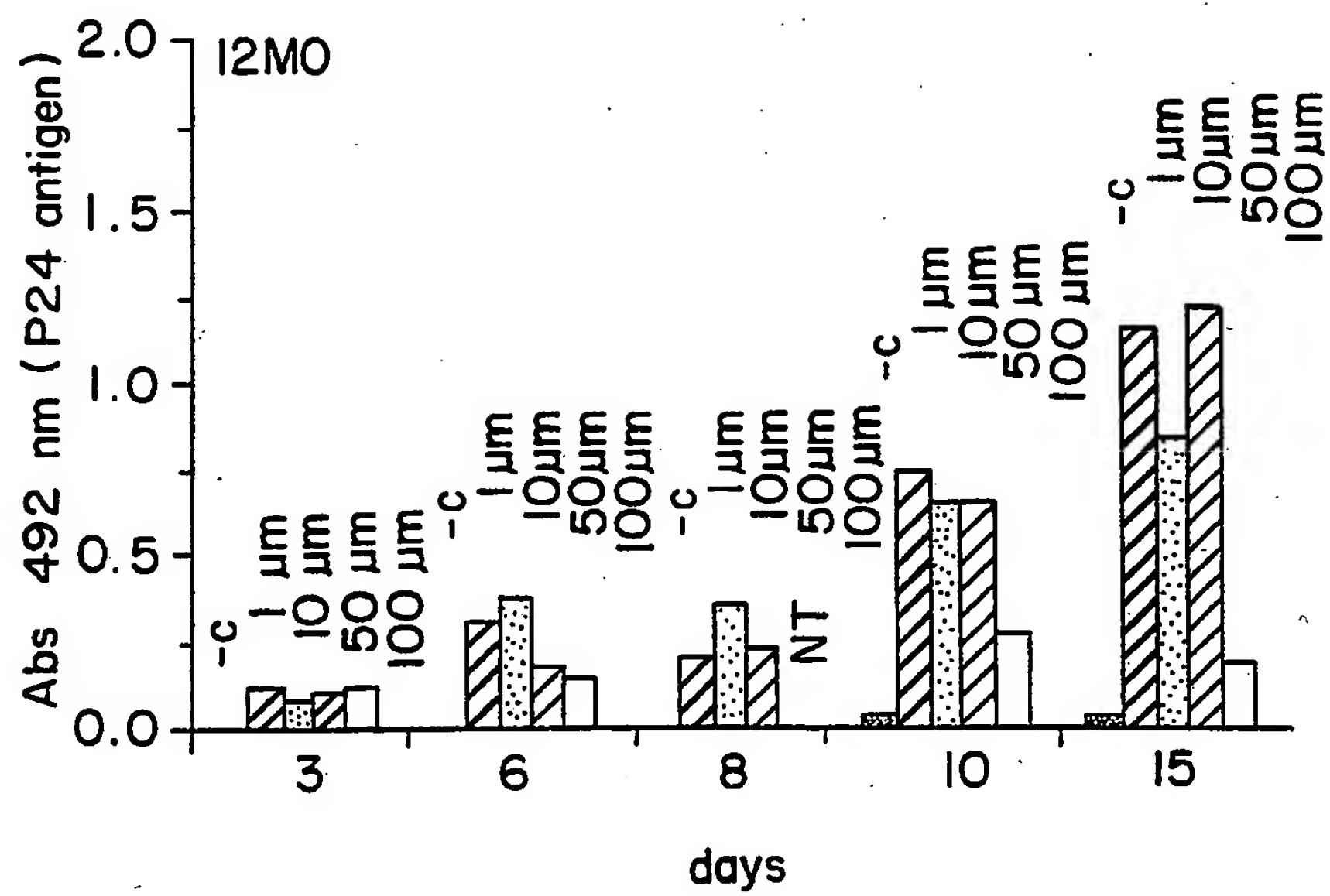
FIG. 2B



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FIG. 2C



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FIG. 3A

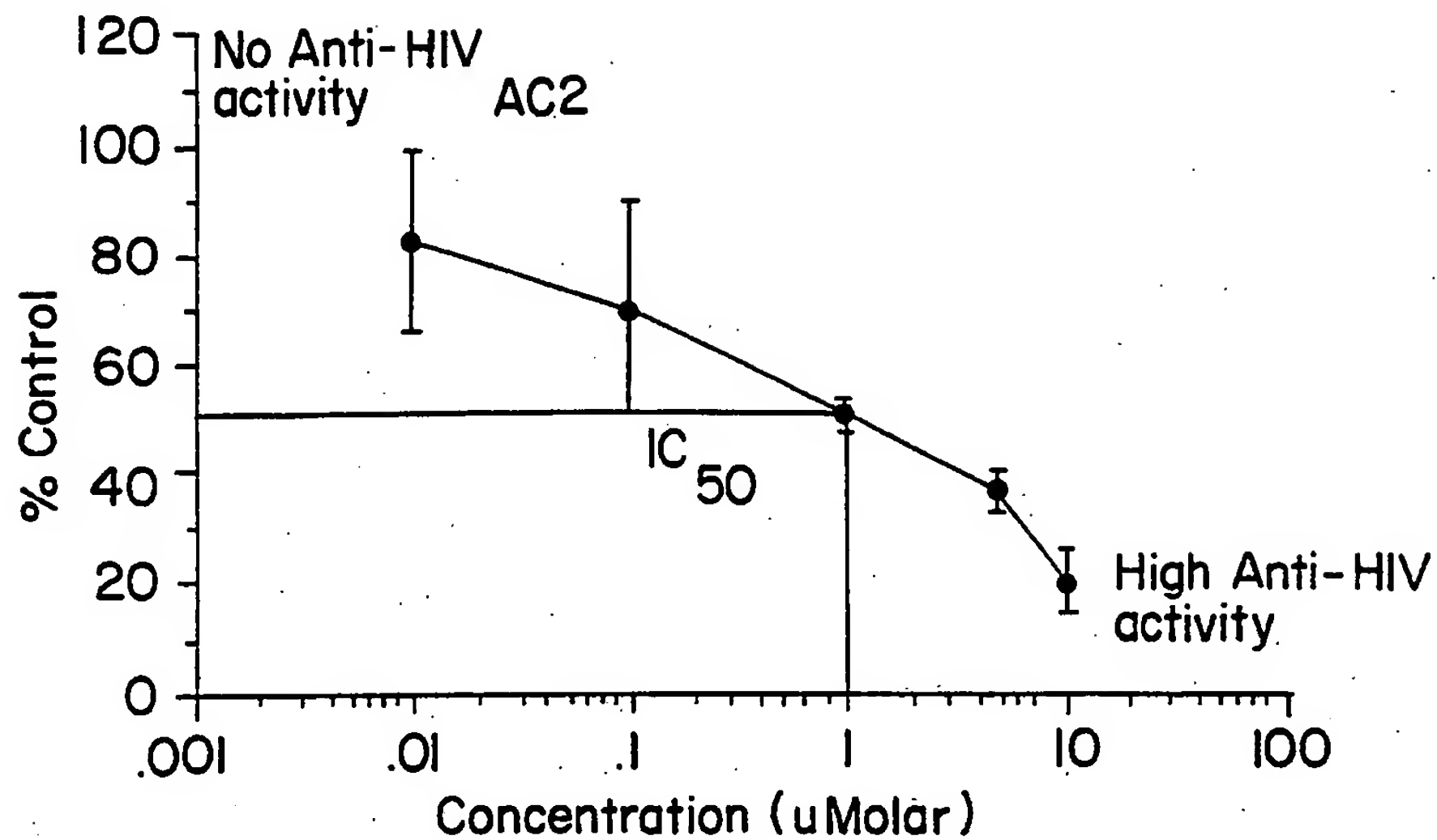
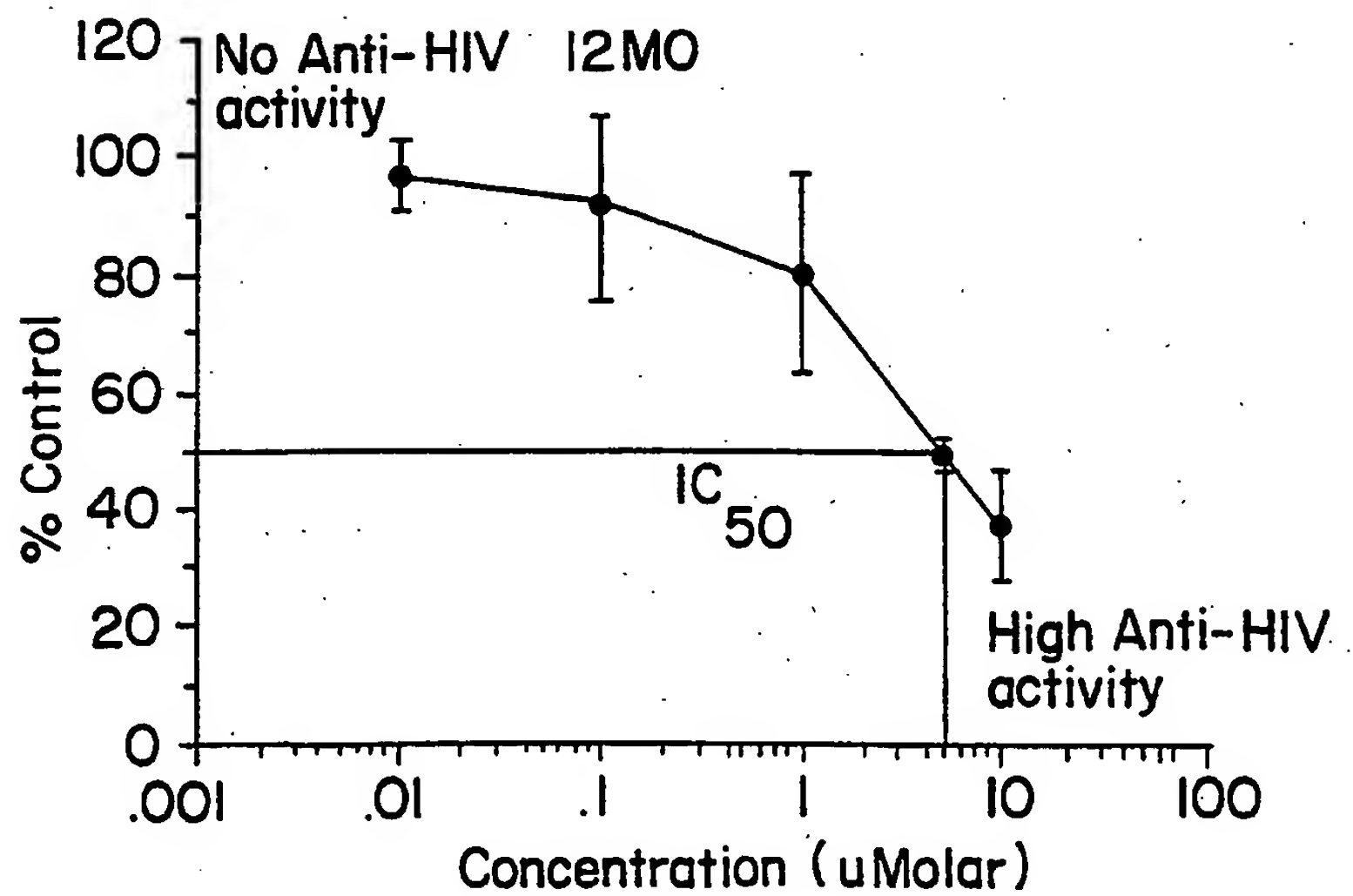


FIG. 3B



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FIG. 4A

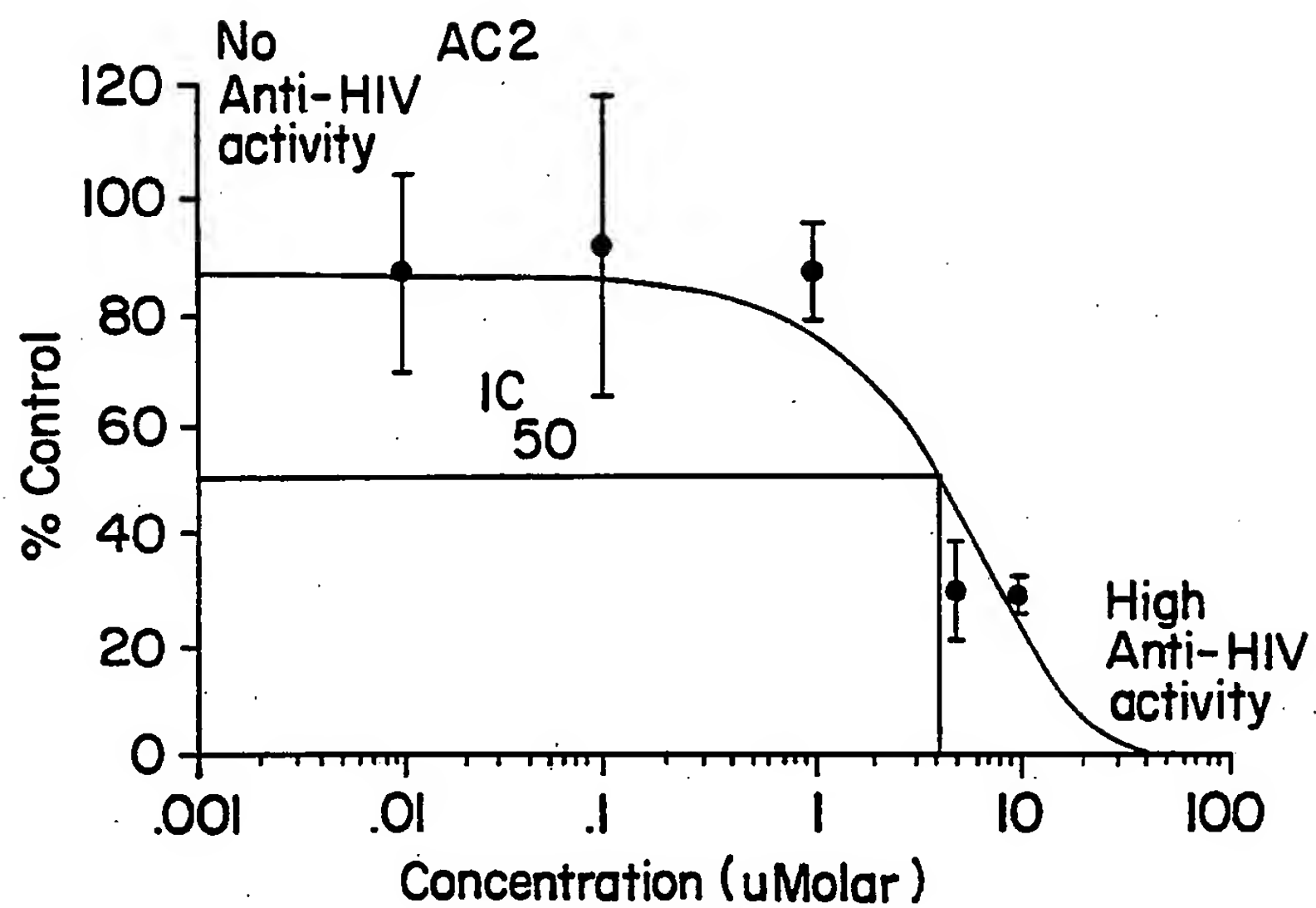
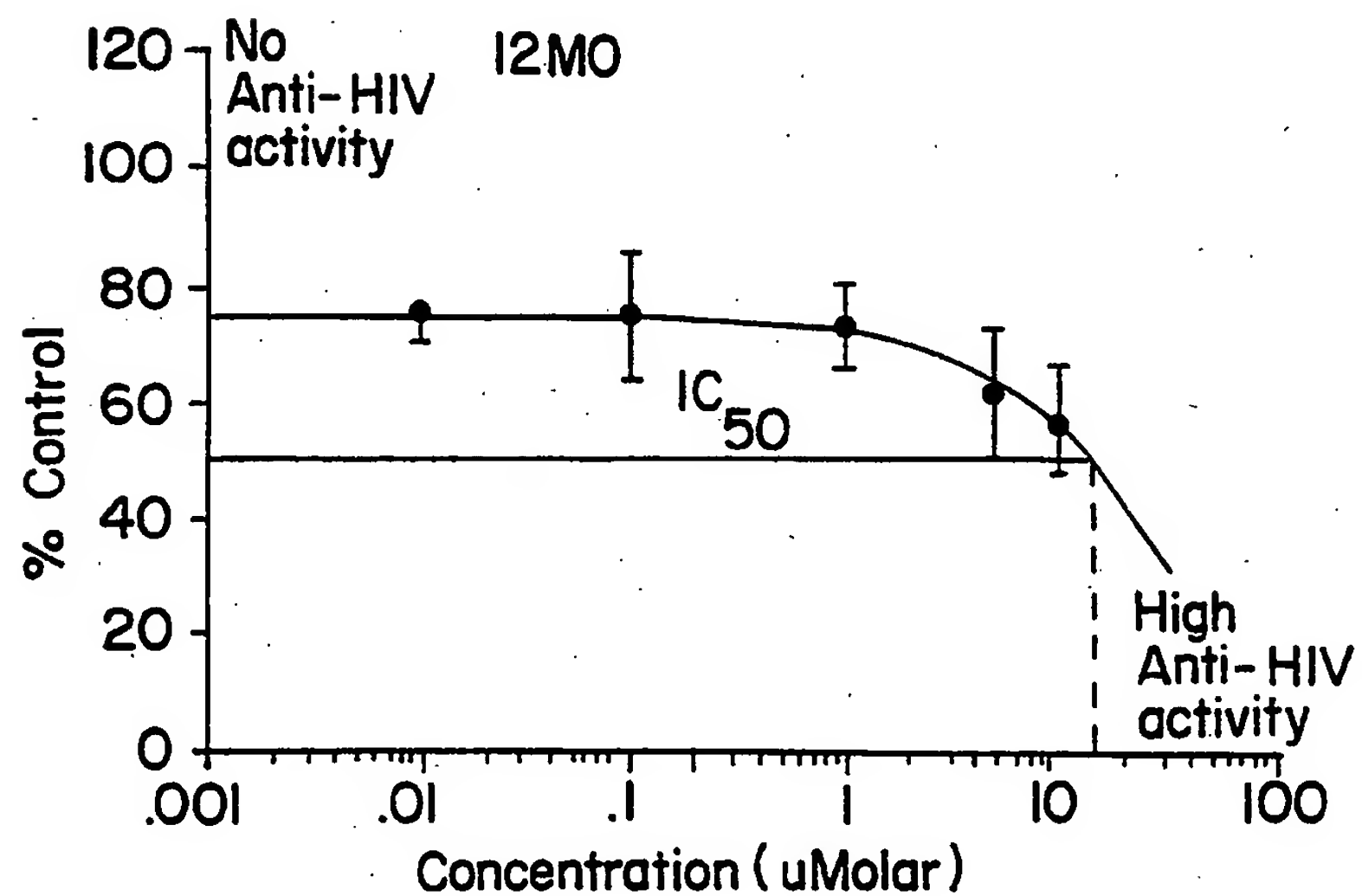


FIG. 4B



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FIG. 5A

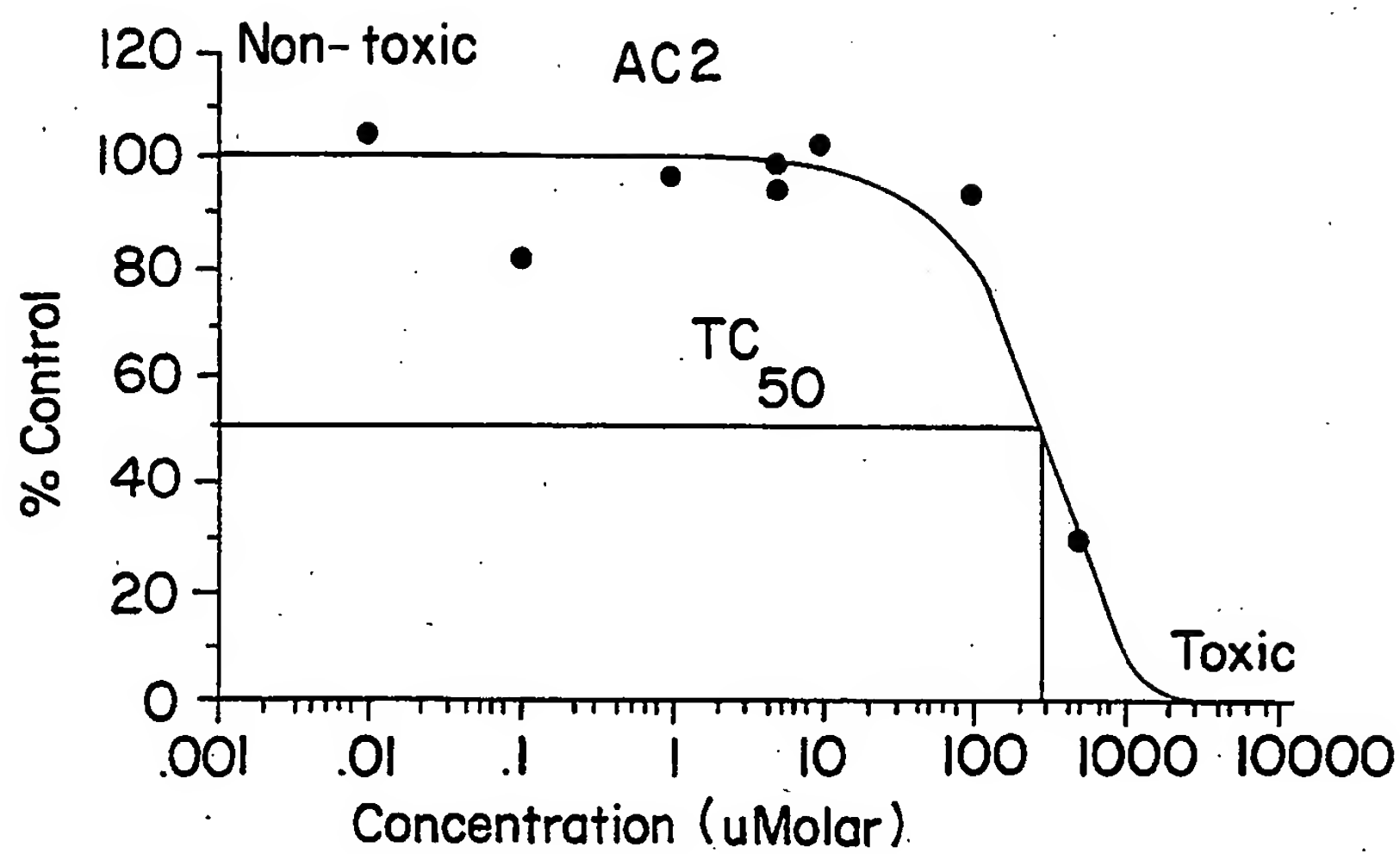
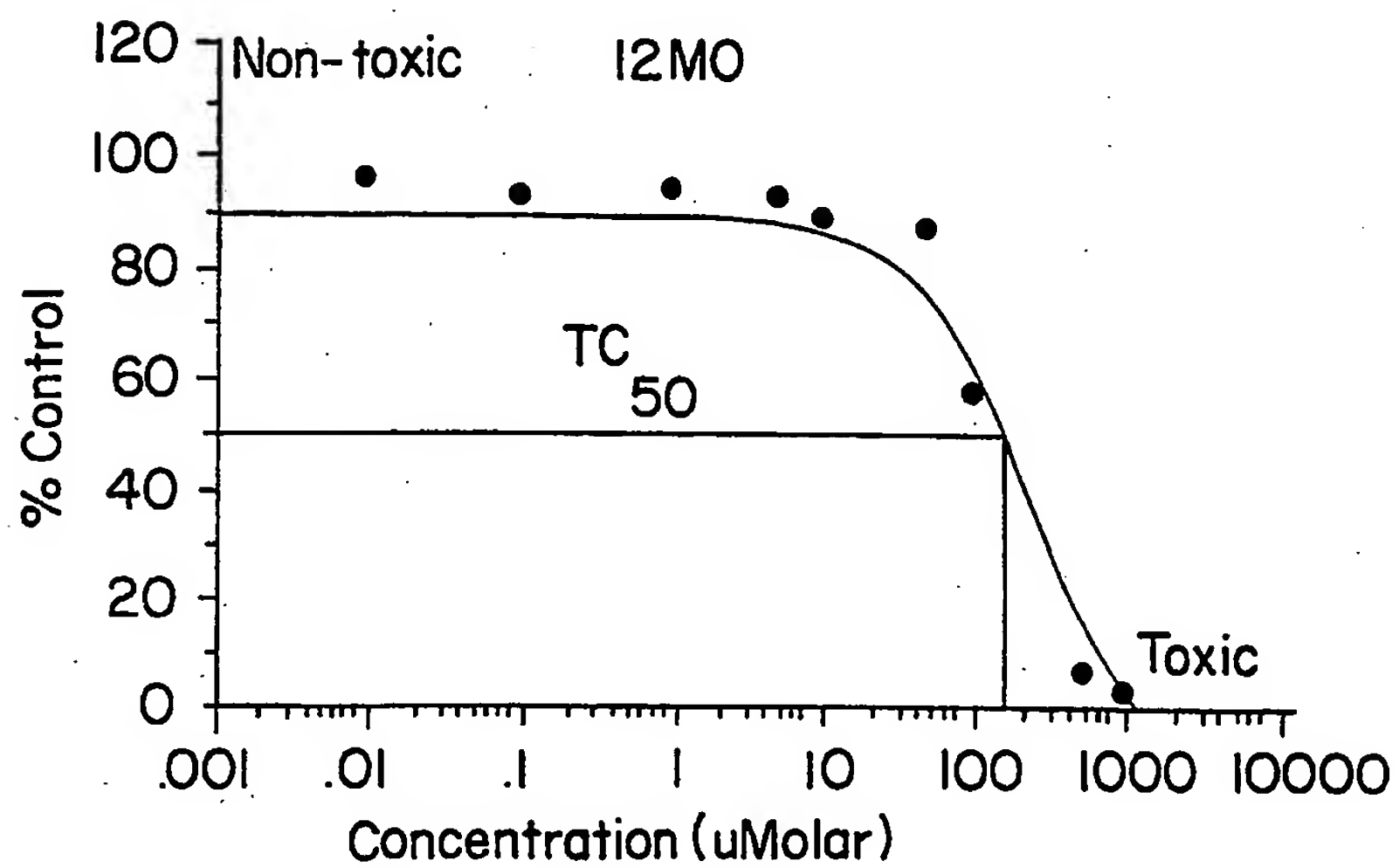


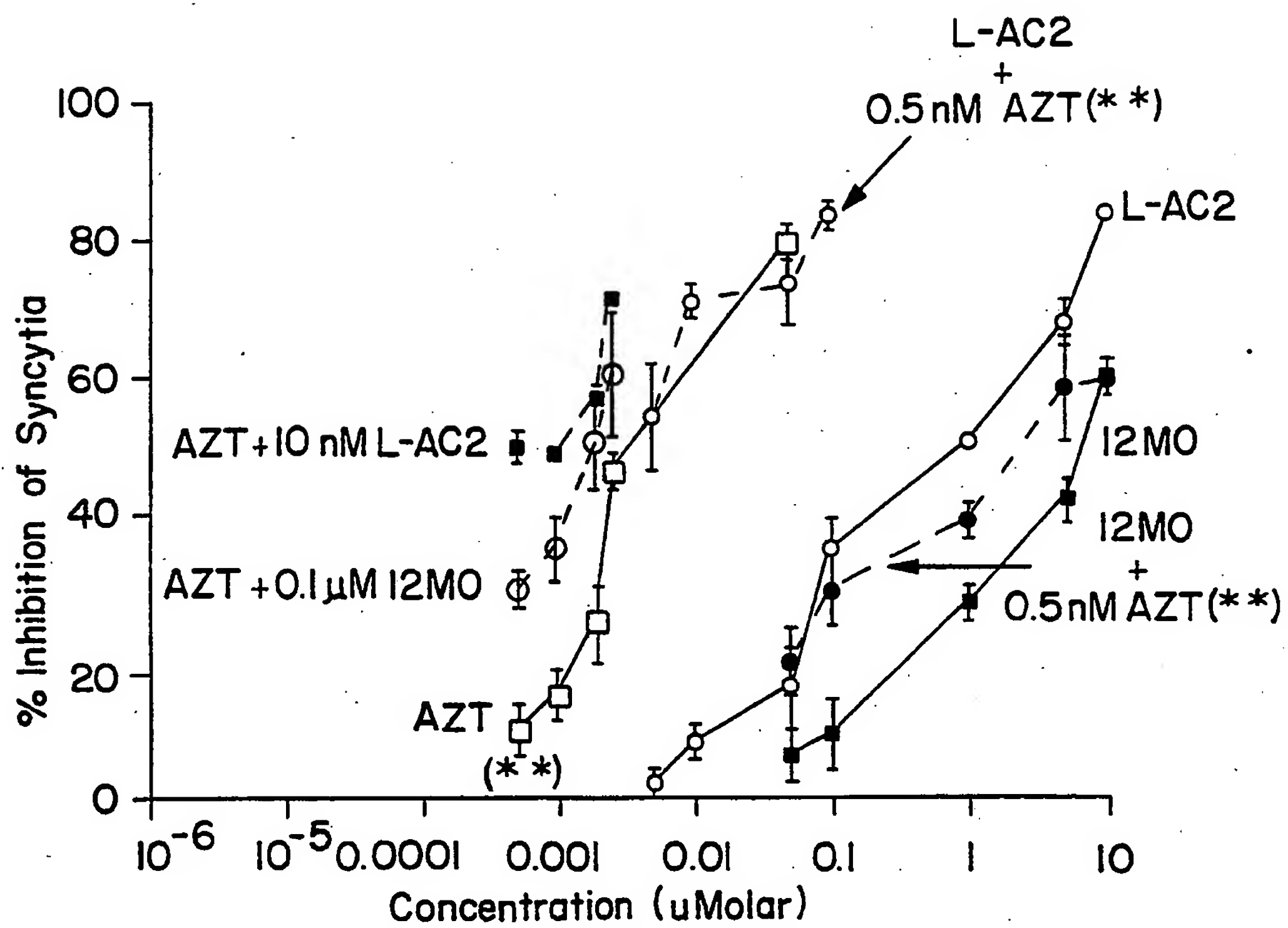
FIG. 5B



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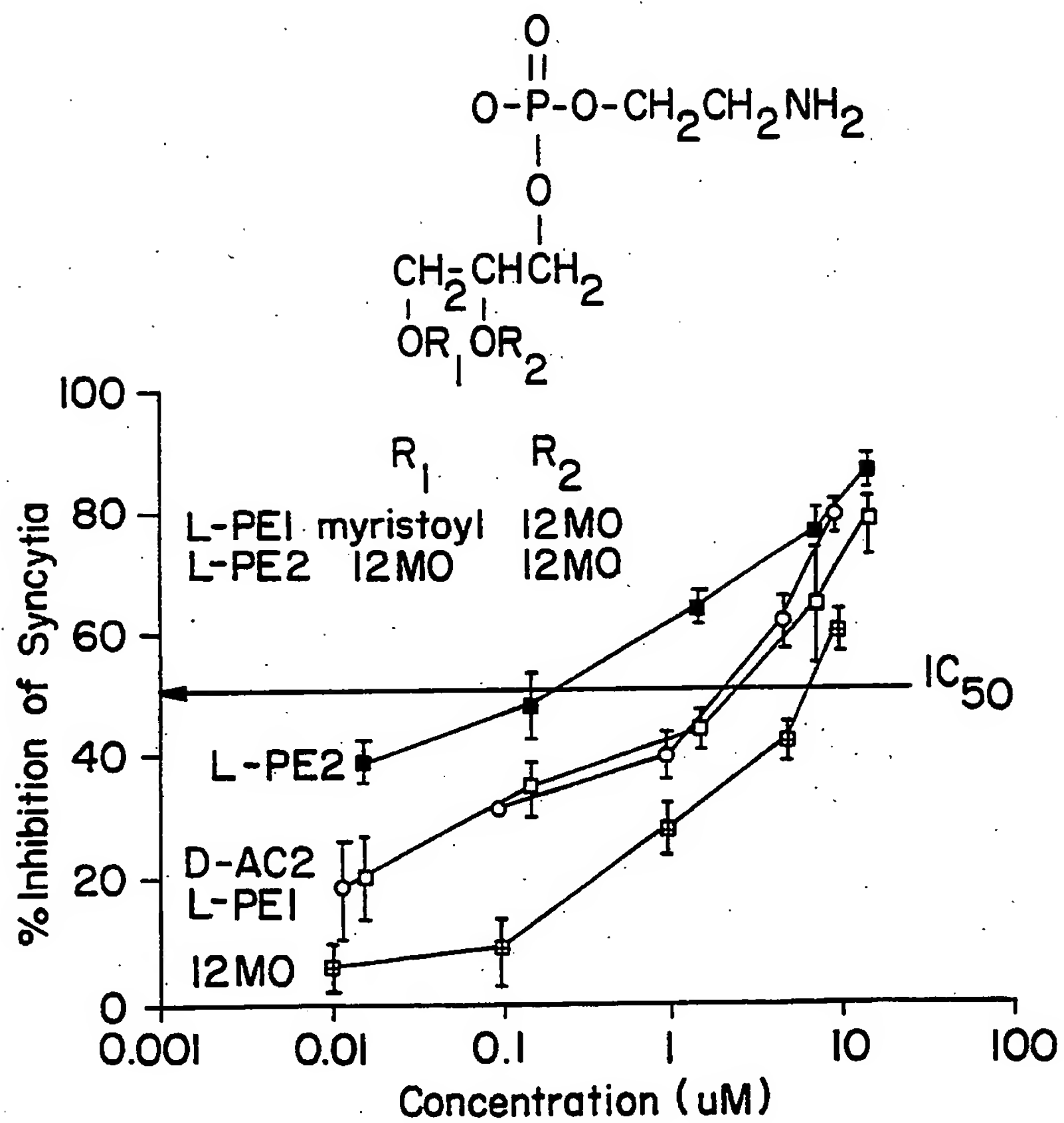
FIG. 6



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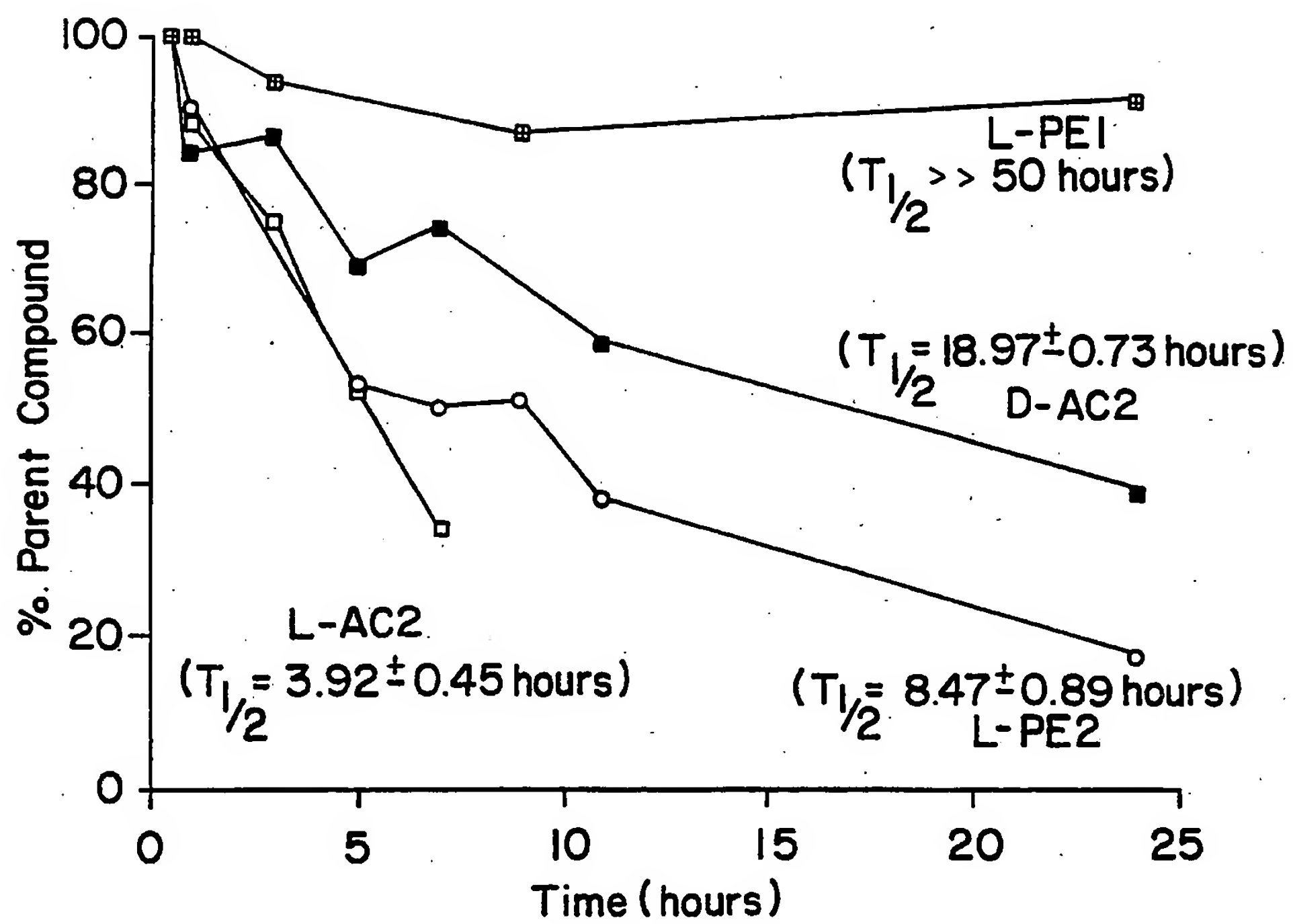
FIG. 7



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FIG. 8



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INTERNATIONAL SEARCH REPORT

International Application No

PCT/US 93/03650

I. CLASSIFICATION OF SUBJECT MATTER (If several classification symbols apply, indicate all) ⁶		
According to International Patent Classification (IPC) or to both National Classification and IPC		
Int.Cl. 5 C07F9/10; A61K31/66; C07F9/117		
II. FIELDS SEARCHED		
Minimum Documentation Searched ⁷		
Classification System	Classification Symbols	
Int.Cl. 5	C07F ; A61K	
Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched ⁸		
III. DOCUMENTS CONSIDERED TO BE RELEVANT⁹		
Category ¹⁰	Citation of Document, ¹¹ with indication, where appropriate, of the relevant passages ¹²	Relevant to Claim No. ¹³
A	EP,A,0 415 902 (WASHINGTON UNIVERSITY) 6 March 1991 cited in the application see the whole document ---	1,41-44
A	EP,A,0 316 117 (SCIENSCOPE INTERNATIONAL N.V.) 17 May 1989 see the whole document -----	1,41-44
<p>¹⁰ Special categories of cited documents : ¹⁰</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> <p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art</p> <p>"&" document member of the same patent family</p>		
IV. CERTIFICATION		
Date of the Actual Completion of the International Search 18 JUNE 1993		Date of Mailing of this International Search Report - 5. 07. 93
International Searching Authority EUROPEAN PATENT OFFICE		Signature of Authorized Officer BESLIER L.M.

**ANNEX TO THE INTERNATIONAL SEARCH REPORT
ON INTERNATIONAL PATENT APPLICATION NO.**

US 9303650
SA 73327

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

18/06/93

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP-A-0415902	06-03-91	US-A- 5073571	17-12-91
		CA-A- 2024489	02-03-91
		JP-A- 3109322	09-05-91

EP-A-0316117	17-05-89	AU-A- 2619988	01-06-89
		JP-T- 2502096	12-07-90
		WO-A- 8904314	18-05-89
